ULTRA-VIOLET RADIATION AND THEIR USES

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Ultra-Violet Radiations and their Uses

BY

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WITH A FOREWORD BY
SIR NORMAN WALKER

WITH FIFTEEN ILLUSTRATIONS

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TO

SUFFERERS FROM LUPUS

FOR WHOSE BENEFIT THIS TREATMENT WAS
FIRST INTRODUCED AND WHOSE GRIM
LOT IN LIFE IS RARELY REALISED
THIS BOOK IS DEDICATED

FOREWORD

DR AITKEN has done a service to the profession by providing in compact form a summary of present knowledge of the Ultra-Violet Radiations, and of their uses as Therapeutic Agents.

He writes of the experience of seventeen years of the work, and of an even longer experience of the treatment by other methods of many conditions in which the use of Radiation is sometimes urged by writers in whom enthusiasm outruns judgment. Here and there in his pages, Dr Aitken comments on this fanatical devotion to this "one and only" treatment: surely it must have been a practical joker who suggested that Ultra-Violet Rays was the best treatment for Scabies!

His dedication of the book to "Sufferers from Lupus" comes from the heart. I shall never forget how much of its success the Lupus Clinic in the Royal Infirmary owed to Dr Aitken's never-failing interest and devotion

NORMAN WALKER.

April, 1930.

ACKNOWLEDGMENTS

To Sir Norman Walker, who instituted the first clinic in Scotland for general radiation treatment, I am indebted for his kindness in writing the Foreword, for the loan of the block for the illustration of the section of the skin, and for the readiness with which he placed his patients at the Royal Infirmary at my disposal for the carrying out of any investigations I desired. To Dr Cranston Low I am indebted for granting similar facilities; to Mr Frank E. Jardine, F.R.C.S., for revising the chapters on the uses of radiations in tuberculosis and surgery; to Dr C. W. Graham for kindly criticism and co-operation in ophthalmic work; to Mr T. H. Graham, Librarian of the Royal College of Physicians, for help with proof-reading and the bibliography; and to Miss Rae for help with proof-reading and the index.

I desire to express my thanks to Messrs Kelvin, Bottomley and Baird, Ltd., for the loan of the blocks for the illustrations of the mercury vapour lamps.

ROBERT AITKEN.

EDINBURGH, *April* 1930.

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ULTRA-VIOLET RADIATIONS AND THEIR USES

CHAPTER I

INTRODUCTORY AND HISTORICAL

Benefits derived from the Sun. Sun-Worship among the Ancients. Reasons for its Decline. Reasons for Narrow Sunless Streets. Advent of Industrial Age. Attempts to Purify the Atmosphere. Some Landmarks in the History of Ultra-Violet Treatment.

SUNSHINE plays an important part in the household of Nature, and without the sun there could be no life upon the earth. Alterations in the relative positions of the sun and earth give us night and day, the changing seasons with seedtime and harvest. Nor does the enumeration of all the forms of life we see around us exhaust the list of the benefits we derive from the sun. At night, whether we read by gas or electricity, whether we sit in front of a gas fire, an electric radiator, or a coal fire, we are indebted to the sun. The two former are obtained from the latter, and coal taken from the depths of the earth represents the energy of the sun as stored in the forests of bygone ages.

When we reflect on all the blessings conferred on mankind by the sun, it is not a matter for surprise that the ancients should have worshipped it. This worship of the sun was not confined to the ignorant barbarian, but was found in cultured Egypt long before

the time of the Christian era. It is interesting in this connection to recall that Akhnaton, the father-in-law of Tutankhamen, gave up some of the other Egyptian gods and worshipped more and more the Sun god, to whose honour he built a new city and new temples. The exquisite beauty of the relics found in the tomb of Tutankhamen who succeeded Akhnaton, reminds us of the sumptuous splendour of those times, and Professor Breasted[1] declares that sculpture in Akhnaton's day reached a pitch of excellence never before known.

In more recent times, the Greeks and Romans realised the value of the sun, and while not worshipping it directly, they understood its health-giving properties. Hippocrates practised heliotherapy on the Island of Cos in the fourth century before Christ. Nearer our own times, we have evidence of the Roman knowledge and use of the health-giving qualities of sunlight in the *solaria* which were built by many wealthy Romans at their country villas. Later still, we have sun-worship as part of the religion of the Aztecs in Mexico.

This cult of the sun seems to have been looked upon as pagan, and with the advent of Christianity there came a revulsion of feeling, and the practice of sun-worship fell into abeyance. The pendulum swung too far, and in addition to the decline of sun-worship there seems to have been a lack of recognition of its beneficial properties, and it is only comparatively recently that the benefits of sunshine have again been realised.

The need of walled towns for purposes of defence in the Middle Ages and later, led to narrow streets with little chance of sunshine for the inhabitants. Even when the need for defence had passed away, habit seems to have made the people build their

houses with comparatively little space between. Not content with the diminution of the beneficial results of sunshine thus brought about, the Legislature imposed a tax on windows, and one still sees in old houses windows which were built up in an attempt to diminish the burden of the tax. This window tax was repealed only in the middle of last century. These conditions were intensified by the rapid expansion of some of our towns as the result of the advent of the industrial age, and more and more of the inhabitants were deprived of the benefits of sunshine. This industrial era aggravated this deprivation in another way. The smoke which was poured out of chimneys, both factory and domestic, lay as a pall over the towns and further reduced the amount of sunshine which they received. Dense fogs, the result of the soot in the atmosphere, blanketed the sun, sometimes for days. In connection with the pall of smoke over towns, it would seem that this has become less dense during the last few years, and that the outlines of Edinburgh, for example, have been more clearly seen since the coal stoppage of 1926. Whether this clearness of the atmosphere is due to the more extensive use of gas and electricity or to people having learned to do with less coal, or to both of these causes, it is impossible to say, but there seems to be little doubt that the atmosphere is now definitely clearer.

Recently there has been a more determined attempt to rid our cities of this pall of smoke by the efforts made to generate electricity from water-power. This effort is all to the good and ought to be warmly welcomed, but it is doubtful if the heating of our houses with electricity will be widespread or thoroughly successful until alterations are made in the type of apparatus supplied for heating purposes. At present

electric radiators give a dull red glow, and when the room is heated there is a sense of stuffiness in the atmosphere. What is required is a radiator which will give a more yellow glow. Radiants for gas fires are now available which give a yellowish flame, and the heat from such radiants is more pleasant than that produced by the older type which gave a dull red glow. Until electric radiators are produced which give this yellow glow, gas fires will continue to be more popular than electric heaters. This means that coal must be burned to produce the gas, and in this way the smoke over our towns will not be much lessened, as it is not practicable to manufacture gas at any considerable distance from the towns where it is to be used on account of the leakages and loss of pressure which take place when gas is carried over a long distance. Even when electricity is produced by steam plant, soot, smoke and noxious fumes are poured out over the countryside. Recently a large town had a decision given against it in a litigation in connection with the nuisance from its smoke and fumes.

The earliest step in the scientific utilisation of light for therapeutic purposes was the discovery of the bactericidal properties of light by Downes and Blunt[2] in 1877, and it was upon this that Finsen founded the treatment called after him. It was in 1893 that he published his first results, and while these were obtained by local treatment of the diseased part only, it ought not to be forgotten that he proposed, as Reyn[3] points out, utilising the sun or artificial light to irradiate the whole body. He died before he could finish his work on light-bath treatment, and it was left to others to continue the experiments which he had begun.

In 1900, Finsen apparatus was installed through the generosity of Queen Alexandra in the London Hospital

for the treatment of lupus, and it is to the pioneer efforts of Dr Sequeira in the Skin Department there that we owe so much of our knowledge of ultra-violet ray therapy to-day.

Early this century, Bernhard and Rollier on the Continent began treating cases of surgical tuberculosis with sunshine, and a few years later Gauvain in England followed suit. While these three workers deserve all credit for their pioneer efforts in heliotherapy, it is through the Finsen Institute workers that light treatment obtained its present independent position.

In 1904, Kromayer invented the water-cooled mercury vapour lamp which bears his name, but little was done in the way of treatment of diseases other than tuberculosis till Huldschinsky showed that rickets could be cured by general exposure to the mercury vapour lamp. Since then workers in all parts of the world have taken up the subject, and the treatment has acquired a recognised place in medicine and surgery.

CHAPTER II

PHYSICS OF RADIATION

Composite Nature of Light. Light an Electro-Magnetic Phenomenon. The Electro-Magnetic Spectrum. Unit of Measurement of Ultra-Violet Waves. Electronic Theory of Matter. How Electro-Magnetic Waves are Produced. Fluorescence. Parts of Electro-Magnetic Spectrum. Parts of Ultra-Violet Spectrum used in Therapeutics.

To Sir Isaac Newton is due the credit for showing that sunlight is not a simple colour but is composite. If a beam of light is passed through a prism it is broken up into its component parts and we get the familiar colours of the rainbow stretching from red to violet. These constitute the visible parts of the solar spectrum. The spectrum, however, extends far beyond these limits which Newton described, and our knowledge of it has been acquired only bit by bit. Herschel found that when a thermometer was placed on a spectrum obtained by passing a beam of light through a prism, the rays falling on it produced a rise of temperature, and that this rise was greater at the red end of the spectrum than at the violet. He also showed that no rise of temperature took place when the thermometer was placed beyond the violet end, but that a rise occurred when the thermometer was placed beyond the red end of the spectrum. He thus proved that there were invisible rays coming from the sun which carried energy in the form of heat. From their position in the spectrum these rays are called the infra-red rays.

A year after Herschel's discovery, Ritter found that there were invisible rays beyond the other end of the spectrum also. It had previously been known that when silver chloride is exposed to light it gradually darkens till it becomes black, and Ritter showed that this property of light extended beyond the violet end of the spectrum and was really greatest beyond it. From their position these invisible rays are called the ultra-violet rays. They are also known as the actinic rays.

It is now well known that light is a form of wave motion. It is interesting to note that Newton believed that light consisted of streams of small particles, the red rays being the largest particles and the violet the smallest. The emission theory of Newton prevailed for a century after his death, and then Thomas Young propounded his wave theory of light. Unfortunately, Young's theory was ridiculed at home and it was on the Continent that the truth of his theory was first recognised and its principles established owing to the work of Fresnel, a French civil engineer.

According to this wave theory the different colours are due to waves of different lengths, the red being due to longer waves than the violet. These waves are not appreciated as colour till they impinge on the retina and are interpreted by the brain. As these light waves are able to travel through space, it is supposed that space is filled by a medium which will allow of wave motion, and this medium is called the ether. Light, therefore, is a series of etheric vibrations which travel at the rate of approximately 186,000 miles per second. No matter what the length of the wave may be, it travels at this rate and consequently a greater number of short waves pass a given point during a given interval of time than of long waves. Short waves

are therefore said to have a greater frequency than long waves. To permit of travelling at such a speed the medium traversed by the waves must be very dense. According to Sir Oliver Lodge[4] the density of ether compared with water is as 1 followed by 12 0's to 1. The same authority goes on to say:—

"The rate of propagation of ether waves depends on the ratio of elasticity to density. It is that which determines the velocity of light; but the velocity of light is known: so if the density is granted, the elasticity is known too. It must be expressed as 1 followed by 33 0's. It is excessively great!"

It was not till the middle of last century that the true nature of light was realised, when Clerk Maxwell proved that it was an electro-magnetic phenomenon. He reasoned that electro-magnetic waves, hitherto undetected, must exist, and he worked out the exact characters of these waves. His genius laid the foundation of all the work done since. Stimulated by his work, Hertz began his researches; but it was not until 1887, nine years after Clerk Maxwell's death, that he succeeded in proving Maxwell's theory by producing and timing electro-magnetic waves. The waves which he produced were the longer ones used in wireless telegraphy, and these are known as Hertzian waves. To these two scientists is due the credit for discovering and putting on a scientific basis our knowledge of these electro-magnetic phenomena. Hertz, however, was not the first to send wireless signals. As not infrequently happens, earlier work has been overlooked. Some fifty years before Hertz succeeded in producing the electro-magnetic waves which bear his name, a Scottish schoolmaster of Dundee, James Lindsay by name, had succeeded in sending wireless signals across the Tay. Though his method of sending these signals differed

from Hertz's, Lindsay was the pioneer of wireless telegraphy. Unfortunately, he did not realise the importance of his discovery. It required Maxwell to reason that the unseen waves upon which it depends, existed, and finally Hertz demonstrated and proved the matter conclusively.

Just as the waves which produce the different colours have different lengths, so other electro-magnetic waves have different lengths. We have the Hertzian waves used in wireless telegraphy. These measure from more than a mile long through the whole range we are familiar with in broadcasting, down to those of a few metres. Shorter than those are the invisible heat rays, then the visible rays passing from red to violet. Next comes the region of the ultra-violet rays and we pass from that to the long X-rays, then to the short X-rays, and so to the gamma rays of radium. Finally, we come to the cosmic or Millikan rays, which are the shortest known rays.

As we pass down the whole of this electro-magnetic spectrum, the length of the waves of which it is composed getting steadily smaller and smaller, we find that it would be cumbersome to talk of wave-lengths in fractions of a metre or even of a millimetre. Two other units of measurement are therefore employed, the $m\mu$ or millimicron, which is a millionth part of a millimetre, and the Ångström Unit, which is so named after the Swedish physicist, and which is a ten millionth part of a millimetre. Throughout this book the Ångström Unit will be the unit of measurement employed, for convenience using the symbol Å.U.

Before considering the production of electro-magnetic waves, it is perhaps advisable to study briefly the structure of matter. Formerly physicists tried to

explain the ether in terms of matter, but their efforts did not meet with success, and now matter is being explained in terms of the ether.

The atom was formerly looked upon as the smallest particle of matter, but it is now considered large compared with the particles which compose it. Matter is now regarded as being composed of two different kinds of electrical particles, the proton and the electron, the former having a positive electric charge and the latter a negative charge. The proton is about 1840 times heavier than the electron, though probably not larger, and it has been suggested that this difference in weight is due to the proton being solid, and the electron a hollow sphere. All matter is built up of protons and electrons in different numbers and in varying arrangements, but with an equal number of each. The atom of hydrogen, which is the lightest element, has one proton which forms the nucleus, and one electron which circles round it like an attendant planet. Helium, the next lightest element, has two protons and two electrons. The protons and one electron are tightly held together to form the nucleus, the remaining electron circling in an orbit round it. As we proceed through the list of elements, we find the atom becoming more and more complex and with an ever-increasing number of protons and electrons, till we reach uranium, which has 238 protons and electrons. Of the electrons, 146 are bound up with all the protons to form the nucleus, while the remaining 92 revolve in their orbits round this nucleus.

It is known that the elements follow a certain definite arrangement. Mendeleev, a Russian chemist, observed that an element does not resemble its neighbour in its properties, but certain others which come at definite intervals in the series. Thus the alkalis are

not placed together in the list of elements arranged according to their atomic weight, but are found in the third, eleventh, nineteenth, etc., places in the series. Other elements similar in properties are separated in a like manner. This arrangement is called the "periodic law," and it was formulated about 1870. One of the groups of elements was not known at the time the law was defined, but all its constituents have been discovered since. This group is composed of the inert gases, helium, neon, argon, etc., so described because they will not enter into chemical combination with any other elements. It is said to be the arrangement of the electrons which is responsible for this property.

It is not definitely known how the electrons are arranged in atoms other than that of hydrogen, but it is practically certain that they are arranged according to a definite plan in rings, which may be circles or ellipses. If one studies the list of elements, it will be found that each period begins with an alkali and ends with an inert gas.

Niels Bohr [5] has suggested that the electrons are arranged in rings and that the inert gases have as many electrons in the outer ring as it will hold, and that this is the reason that these gases cannot unite. According to his theory the outer ring has always the same number of electrons, eight, when it is complete, except hydrogen and helium. There would seem to be a tendency for atoms to combine so as to make up the full number of electrons in the outer ring, and the chemical properties of an element will depend almost entirely on the electrons in the outer ring.

The electrons are attracted by the nucleus but are repelled by the other electrons, both in their own orbit and in neighbouring orbits. Their position is not fixed, they can be moved from an outer to an inner orbit,

and when this occurs, light, ultra-violet rays, or X-rays are produced according to which electrons are disturbed. In a similar way an electron may be made to pass from an inner to an outer orbit, and it may even be detached from the atom altogether and under certain circumstances be photographed rushing about quite free and unattached.

When an electron is detached from an atom, there is an excess of protons left in the atom, and it then becomes positively electrified. The detached electron is of course negatively electrified. Under certain circumstances an atom can be made to acquire an excess of electrons and in this way it becomes negatively electrified.

When a stone is thrown into water, a series of waves is produced, these getting gradually smaller and smaller till they cease. These waves are due to two properties of water, the power of recoil, which tends to bring the crest back to its normal level and in this case due to the action of gravity, and the power of inertia, so that the mass of water in the wave crest tends to overshoot the level and go below it, thus forming the trough of the wave. The power of recoil is simply elasticity and the overshooting of the mark is inertia, and on these two properties, elasticity and inertia, depends the propagation of the ether waves. When an electron passes from an outer to an inner orbit, a disturbance of the ether occurs and wave motion is thus produced in it, giving rise to light, ultra-violet rays, or X-rays according to the position of the electron displaced. When energy is absorbed into an atomic system, an electron is displaced from an inner to an outer orbit, or it may be thrown out from the atom altogether.

Occasionally when energy is absorbed and an

electron so displaced to an outer orbit, the electron is left in an unstable condition, and when the influence which excited its displacement is removed, it tends to fall back again into its original position, thus creating a disturbance of the ether. If the exciting influence returns, the electron is again displaced outwards, to fall back again as before. In this way the phenomenon of *fluorescence* is produced, invisible rays being transformed into visible rays. Fluorescence differs from phosphorescence in that the former is only produced while the exciting influence is acting, whereas *phosphorescence* persists after the exciting influence has been removed. One of the best-known examples of fluorescence is obtained when a beam of invisible X-rays falls upon a specially prepared screen, the screen is made to glow or fluoresce while the rays are acting upon it, but it immediately ceases to glow when the X-ray influence is cut off.

The electro-magnetic spectrum is a very extensive one, consisting of some 80 octaves, an octave being a section of the spectrum such that the wave-length of the rays at one end is double the wave-length of the rays at the other. Luckiesh[6] has calculated that if the visible portion were one foot long, the entire electro-magnetic spectrum would be several million miles in length. The spectrum is divided into different sections, some sections being long, others comparatively short. As has already been mentioned, the longest waves are the Hertzian or wireless waves, and these extend over several octaves. Next comes the long section of the infra-red rays extending from the Hertzian waves through $9\frac{1}{2}$ octaves, four or five of which are included in the solar spectrum, to the red end of the visible spectrum which is the next in order and is a very short section, being only one octave in length, the waves

ranging from 7800 to 3900 Å.U. The ultra-violet spectrum follows, though only about half an octave of these rays are found in the solar spectrum.

The ultra-violet spectrum has been divided into three parts, the near ultra-violet rays extending from 3900 to 2900 Å.U., the middle ultra-violet rays from 2900 to 2000 Å.U. and the extreme ultra-violet from 2000 to 150 Å.U.

Those rays nearest the solar ultra-violet rays have been analysed by means of quartz prisms and recorded by means of ordinary photographic plates. As quartz, however, will not pass rays of a wave-length shorter than 1850 Å.U., and as rays shorter than this are filtered out by a small column of air, other methods of investigation have to be adopted. Schumann,[7] using lenses and prisms of fluorite in a vacuum, obtained rays as short as 1200 Å.U., and this region of the spectrum is frequently called after him. As gelatine absorbs the rays of this region, Schumann had to use photographic plates whose emulsion was nearly free from gelatine. Lyman,[8] using a concave diffraction grating, obtained waves as short as 500 Å.U. Millikan[9] has now reached the level of wave-length 140 Å.U. This represented the limit of the optical spectrum and there was formerly a gap between this and the X-rays. Dauvillier[10] succeeded in reaching a wave-length of 121 Å.U. Thibaud[11] next succeeded in recording a wave-length of 68 Å.U., and finally Osgood[12] bridged the gap by obtaining wave-lengths of from 45 Å.U. to 215 Å.U. Lyman[13] gives the region between 150 Å.U. and 10 Å.U. as belonging to the soft X-rays which get harder as they get shorter and approach the wave-length 0·1 Å.U., where we come to the gamma rays of radium. Shorter than these are the cosmic rays, which are the shortest known rays.

The section of ultra-violet rays shorter than 2000 Å.U. is of no importance therapeutically. It has been shown that the ultra-violet rays from 3900 to 2900 Å.U. are capable of penetrating a certain thickness of skin, and that the shorter rays do not penetrate the skin to any great extent, but have a strong bactericidal effect, this being greatest between 2800 and 2500 Å.U.

Even the central section is of comparatively little importance therapeutically. One must remember that the ultra-violet rays from the sun do not extend beyond 2900 A.U. and that even some of the shorter of these are filtered out by the atmosphere. It has been shown that three-quarters of the rays of a wave-length shorter than 2600 Å.U. are absorbed by ozone in the concentration of 1 mg. of ozone in a litre of air. This is the more interesting as it seems definite that ozone is formed in the outer layers of the atmosphere by the action of the sun's ultra-violet rays on the oxygen, and at the same time this ozone screens off the shorter ultra-violet rays which are harmful to the body.

The section of ultra-violet rays from 3800 to 2900 Å.U. is the important one therapeutically for most practical purposes.

CHAPTER III

PHYSICO-CHEMICAL ACTION OF ULTRA-VIOLET RAYS

Grotthus' Law. Photo-Electric Change. Photo-Electric Fatigue. Chemical Changes. Changes of Degradation. Changes of Synthesis. Photo-Chemistry in Nature. Action on Ferments and Vitamins. Substances Intensifying or Retarding the Action of Light. Methods of Measuring Intensity of Ultra-Violet Rays.

WHEN a beam of light falls on a substance which absorbs part or all of it, certain changes occur in the substance. It is only the rays which are absorbed that can produce any change; this truth was first enunciated by Grotthus and is known as Grotthus' Law. The rays which are transmitted through the substance have no effect. The changes which may occur when radiant energy is absorbed may be of different types. There may be a change into heat. This, for example, happens when a beam of light falls on a negro's skin.

It has already been mentioned that when radiant energy is absorbed into an atomic system, an electron is displaced outwards. It may pass simply from an inner to an outer orbit or ring, and this gives rise to a chemical change only. The electron, however, may be ejected altogether from the atom and this alters the electric charge of the latter, which then becomes positively electrified, instead of being neutral as it was previous to the action of the rays.

This photo-electric change can be observed in gases, liquids, or metals. In the case of gases it is difficult to

get rays short enough to cause this expulsion of the electron, but it has been shown that the free electron in a helium atom can be detached by a beam of X-rays. The atom is left positively charged while the free electron can actually be photographed by the use of special arrangements. Oxygen can be ionised by ultra-violet rays alone. This ionisation of gases may partly explain the observation of Hertz, who found that a spark would pass between the poles of an induction coil if the light from electric sparks were played on them, these sparks being very rich in ultra-violet rays. There is also an emission of electrons from the negative pole, and this is also in part responsible for the passage of the spark. If the light be removed from the pole-plates no spark takes place across the gap.

This photo-electric change can be more easily observed and the effect can be measured by means of a gold leaf electroscope. If the metal is negatively electrified, it loses its charge when exposed to ultra-violet rays, but if positively electrified it retains it. The photo-electric effect has been the object of precise study, and it has been found that the more intense the light, the greater is the number of electrons given off. It has also been noted that if the radiations continue to play on a substance, the emission of electrons diminishes, but will return to normal again after a period of rest. This diminution in the emission of electrons takes place even *in vacuo*. The nature of this *photo-electric fatigue* is not exactly understood.

The chemical effects of light on many substances are well known. A solution of silver nitrate is known to break down under the influence of light, and chloroform must be kept in dark bottles to prevent its decomposition into phosgene and hydrochloric acid. This reaction is sometimes called a reaction of

degradation, a complex substance being broken down into two simpler ones.

In other cases, however, complex substances are built up out of simpler ones under the influence of light. Sometimes this reaction seems to be of the nature of oxidation, as, for example, the transformation of bilirubin into biliverdin. Mention has already been made of the building up of ozone from the oxygen of the air, the change taking place in the upper layers of the atmosphere under the influence of the ultra-violet rays of the sun. The exposure of blood containing carbon monoxide to ultra-violet rays brings about a similar oxidation change, the monoxide being converted into dioxide as has been shown by Benard and E. and H. Biancani.[14] This has a practical application, as it is well known that in cases of carbon monoxide poisoning it is difficult to displace the monoxide, as it forms a firmer combination with the hæmoglobin of the blood. If a patient suffering from carbon monoxide poisoning could be subjected to ultra-violet radiation, the oxidation change would take place and the patient would have a much better chance of recovering. Cases in which this has been done have been reported by Koza.[15]

Sometimes the reaction is of the nature of a reduction instead of an oxidation, as, for example, the reduction of oxyhæmoglobin to methæmoglobin, as has been done by Bordier and Nogier.[16]

In some cases instead of being a simple oxidation or reduction, the action is more complex as in the conversion of lactic acid into alcohol and carbonic acid.

As an example of the more complicated changes due to light, we have those occurring in plants under the influence of light. The sunlight and the green plant break up the carbon dioxide of the atmosphere.

The plant rejects the oxygen but retains the carbon and builds it up into carbohydrates such as starch and sugar. It is the chlorophyll which is responsible for breaking up the carbon dioxide, for starch is formed in the chlorophyll granules, and when these are absent the starch is not found. It has been suggested that the red rays are the most active in bringing about this change, but in view of certain laboratory experiments which have been carried out, this is doubtful. Thus Berthelot and Gaudechon[17] have been able by ultra-violet rays alone to bring about a series of reactions similar to those produced by sunlight and chlorophyll. The four stages of their experiments are :—

1. Decomposition of carbon dioxide into carbon monoxide and oxygen (action reversible)

$$2CO^2 \rightleftharpoons 2CO + O^2.$$

2. Decomposition of water into hydrogen and oxygen (action reversible)

$$2H^2O \rightleftharpoons 2H + O^2.$$

3. Combination of hydrogen and carbon monoxide to form formic aldehyde (action reversible)

$$CO + H^2 \rightleftharpoons CH^2O.$$

4. Polymerisation of the formic aldehyde to form sugars

$$n(CH^2O) = (CH^2O)n.$$

Similarly, Baly[18] of Liverpool has found that sugars can be formed from comparatively simple compounds by the action of ultra-violet rays. The beneficial effects of sunlight on plant growth is shown by the fact that sugar-cane has been found to contain 30 per cent. more sugar when grown in plain sunlight than when grown in sunlight deprived of its ultra-violet rays by means of coloured glass screens.

Many other examples of the chemical action of light and ultra-violet rays on substances could be quoted, but sufficient have been given to indicate the extraordinary variety of the changes produced.

Much work has been done on the action of ultra-violet rays on chemical substances, and it has been found that in some cases the properties of ferments are destroyed by radiation as Downes and Blunt[19] have shown for saccharose. Vitamins also may be destroyed by radiations. Thus Peacock[20] found that the vitamin A is destroyed when cod-liver oil is exposed to light, and in addition the oil loses its fluorescence. The latter returns when the oil is kept in the dark, but the former does not. Other workers have confirmed this destruction of the antiscorbutic vitamin by exposure to radiation, Reyher[21] showing that the vitamin A in milk is destroyed after radiation.

Certain substances intensify the action of light or of certain sections of the spectrum. It is well known that ordinary photographic plates are insensitive to red light though sensitive to the green-violet end of the spectrum. In 1873, Vogel[22] observed that certain dyes which absorbed green, yellow and red, would render a collodion emulsion of silver bromide sensitive to these colours. Waterhouse[23] about the same time showed that erythrosin conferred a pronounced degree of sensitiveness to the yellow-green region, and this dye is in regular use for the manufacture of orthochromatic or isochromatic plates. German scientists are responsible for the discovery that the isocyanine dyestuffs rendered photographic plates sensitive to red light and thus made possible the manufacture of panchromatic plates. Many other dyes are employed to make plates specially sensitive to particular parts of the spectrum. Other chemicals such as phenosafranine

pinacryptol and pinacryptol-green make plates less sensitive to the action of light. These are used photographically as desensitisers, and by their use plates can be developed by ordinary light.

In some cases the action of chemical substances seems to be catalytic. The action of the light would take place in their absence, but it is hastened or retarded by their presence. In some instances the action is slow at first and it becomes progressively more rapid; it has been suggested that in these cases one of two things may happen: a catalytic substance is slowly but steadily destroyed, thus allowing the reaction steadily to accelerate, or a positive influence is built up, the end-result being the same.

The chemical changes induced in certain substances by the action of the rays and the alteration of colour resulting from these changes, have led to the utilising of many different substances in the attempt to measure the intensity of a beam of ultra-violet rays.

Saidman and Monceaux[24] make use of the fact that a solution of paraphenylenediamine, which is colourless, becomes violet under the influence of ultra-violet rays.

Bordier[25] uses a piece of paper soaked in a 20 per cent. solution of potassium ferrocyanide. On exposure to ultra-violet rays the colour passes from the initial white through all the intermediate stages of cream and sulphur shades to deeper and deeper yellow. His chromo-actinometer consists of five tints and the intensity is estimated by comparing the reacting strip with one of the five tints.

Hill, Eidinow and Webster[26] use an acetone methylene blue solution. The acetone is decomposed by exposure to the ultra-violet rays and decolorisation of the methylene blue results and the amount of this colour change is compared against a standard tint.

Many other chemical measures have been devised for measuring the intensity of the radiations, but it must be remembered that their use is limited to this purpose and that they are of little or no value for dosing the patient.

Other methods for measuring the intensity of the rays may be employed, such as the current and voltage, measurement from a light source of known characteristics, or use may be made of a photo-electric cell. Other methods are based on the ionisation of gases, or the fact that metals emit electrons under the influence of ultra-violet rays, and the number emitted is proportional to the intensity of the light. While these various means are useful in the laboratory, they are, like the chemical methods, of little value in therapeutic work.

CHAPTER IV

BIOLOGICAL EFFECTS OF LIGHT

Methods of studying Biological Effects. Abiotic Action of Rays. Factors influencing it. Susceptibility of Different Tissues. Anatomy of Skin. Penetration of Rays into the Skin. Functions of the Skin. Regulation of Body Temperature. Maintenance of Water Balance. Excretory and Lubricating Functions of Sweat Glands and Sebaceous Glands. Absorption by Skin. Sensory Function. Respiratory Function. Ferments produced by the Skin. Manufacture of Pigment. Less well-known Functions of Skin. Relationship of Skin and Internal Organs. Erythema effect of Light. Alterations of Sensation. Pigmentation. Production of Vitamin D. Effect of Light on Temperature of Skin. Destruction of Toxins by Light. Other Changes in Skin produced by Light. Effects of Light on Blood Cells. Effect on Plasma. Effect on Bactericidal Power of Blood. Effect on Blood Calcium and Phosphorus. Alteration of Alkalinity of Blood. Effect on Blood Sugar. Effects on Endocrine Glands. Carbohydrate Metabolism. Nitrogen Metabolism. Effects on Nervous System.

In order to study the properties of the different parts of the ultra-violet spectrum, use has been made of filters of various substances which allow only certain rays to pass. This has been of great value in the advancement of our knowledge of the effects of the rays. At the present time, however, it cannot be said to be of any great help therapeutically. We do not know much of the mode of action of the rays, and it is not possible at the present time to state that any one section of the rays is the most valuable. A notable

exception to this statement is the section of rays which are anti-rachitic. It has been proved that these lie below the 3300 Å.U. limit; it is also known that they lie above the 2900 Å.U. level, as that is as far as the solar spectrum extends, so that these valuable rays lie between these points. But, generally speaking, we do not know that any one section of the ultra-violet spectrum is chiefly to be desired therapeutically. It is not even certain that the ultra-violet rays alone are the most important rays for therapeutic purposes. We are thus left with a composite beam of rays of widely different wave-lengths, extending from the infra-red heat rays through the visible rays to the ultra-violet rays, and until more is known of the action of the various sections of the spectrum, it is wiser to utilise a bundle of rays as nearly as possible approximating to the rays found in sunshine.

It has already been stated that the rays must be absorbed by a substance before any effect can be produced. It is found that ultra-violet rays are not absorbed equally at all wave-lengths, and experiments have shown that this absorption by albumin is slight for waves longer than 3000 Å.U., below this the absorption rapidly increases to 2800 Å.U., then there is a tendency for it to diminish till the wave-length 2503 Å.U. is reached, when absorption again increases.

The bactericidal property of ultra-violet rays has been studied in connection with many different organisms and other forms of life. It has been proved that it is the shorter ultra-violet rays which have this bactericidal power, and this is in agreement with what has been indicated above about the absorption of the rays. Little absorption takes place above the 3000 Å.U. limit, and consequently there is little bactericidal effect. It would appear that there is a relationship

between the intensity of radiation and the abiotic threshold. The more intense the radiation, the shorter the time required to kill the organisms. It has also been found, however, that if the intensity of the radiation is low, the organisms may recover even when the incident rays are of short wave-length. Pluricellular organisms are much less susceptible to the influence of radiations than are the simple ones, and much greater doses are required to kill them.

Various other factors have an influence on the abiotic action of the rays, some media absorbing the rays more than others. Some organisms are more resistant to radiation than others, and the age of the culture also has a bearing, young cultures being more easily killed than older ones. It would seem that the action of ultra-violet rays on organisms is a direct one on the cell contents, as it has been shown, as long ago as 1911, that ultra-violet rays produce a coagulation of the protoplasm.

Tissues also vary in their susceptibility to ultra-violet rays. Moppett [27] has shown that the kidney is the most easily killed and the spleen the most resistant, the heart occupying an intermediate position. Neoplasms are more resistant than normal tissue.

All the laboratory experiments show the great difficulty there is in arriving at any satisfactory conclusion as to how the rays act in the human body. It has been shown that rays must be absorbed before any chemical change can be effected. The rays fall on the skin, and on the amount and quality absorbed depends their action. If the skin were a simple structure the problem would be easier, but it is a highly complex organ with different layers, each having a different structure and function. To quote Metzner [28]: "The many-sidedness of the tasks which every section

of the skin has to fulfil brings it about that in this thin covering the most varied apparatus are crowded together and interwoven with one another in the smallest space, a circumstance which naturally makes very much more difficult the clearing up of the mechanism participating in the individual functions."

It might be well to recapitulate the **structure and functions of the skin**. We will take the epidermis first, and pass from the deeper layers outwards. Each layer is evolved from the one below it and by following the changes in the way they occur, a better idea is obtained of the structure of the skin and the way in which radiations may affect it and its functions.

The lowest layer of the epidermis, the basal layer or *stratum germinativum*, sometimes known also as the palisade layer, consists of columnar cells which are placed close together and which contain pigment, the amount of which varies according to the colour of the individual. From this layer is formed the prickle layer, the *stratum mucosum* or Malpighian layer. The cells of this layer are separated from each other by lymph spaces, which are bridged by processes of protoplasm passing from one cell to another. It is these processes, which look like spikes projecting from the cells, that give the layer its name of prickle layer. The cells of the prickle layer are at first polygonal, but as they are pushed upwards by the growth of the basal cell layer, they tend to become flattened and lose their prickles. A chemical change then occurs in the protoplasm of the cells leading to the deposition of granules of keratohyalin and the cells thus altered form the granular layer or *stratum granulosum*. A further change now takes place; the cells lose their nuclei and the granules of keratohyalin become changed into a clear substance called eleidin. The cells thus altered

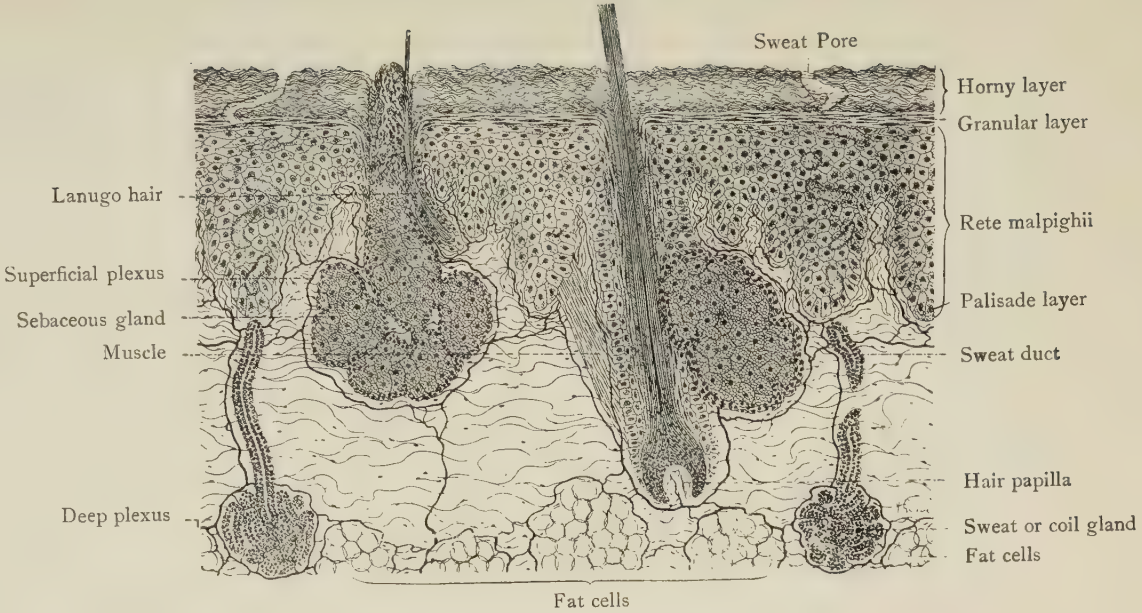

FIG. 1.—Diagram of Vertical Section of Skin.

Reproduced by permission from Walker's "Introduction to Dermatology."

form another layer which is called the *stratum lucidum*, and it is best seen in the palms and soles. Next to this layer we have the horny layer or *stratum corneum*, the lower cells of which contain fat and a waxy substance which makes them waterproof; above them the cells are looser and appear merely to be cell membranes, while above these the cells of the horny layer are densely packed and are constantly desquamating.

Below the epidermis lies the corium, the dermis or true skin. The corium is mainly composed of fibrous tissue. The upper portion or *pars papillaris* dovetails with the epidermis and consists of fine fibres, while the lower portion or *pars reticularis* consists of looser, somewhat coarser fibres. In the corium lie the blood-vessels, lymphatics, and nerves, while the hair follicles, the sebaceous and the sweat glands also lie in this part.

It will be observed that there are no blood-vessels to be found in the epidermis.

Various estimates have been made with regard to *the penetration of the rays into the skin.* It has been stated that rays shorter than 3000 Å.U. do not penetrate through skin 0·1 mm. thick.

Hasselbach[29] gives the percentages of light of various wave-lengths which penetrate skin 0·1 mm. and 1 mm. thick, as shown in the following table:—

Wave-length.	4360.	4050.	3660.	3540.	3130.	3020.	2970.	2890.
0·1 mm. . .	59	55	49	42	30	8	2	0·01
1 mm. . . .	0·5	0·3	0·08	0·02	...	...	...	...

It is more than doubtful if such figures are of any real value; they represent laboratory experiments with dead skin, and it does not follow that the same amount

of radiation is all that will pass through the living cells. Indeed Macht, Anderson and Bell[30] have shown that the penetration of ultra-violet rays of all wave-lengths is much greater in the living tissues than in the dead skin.

This question of absorption of the rays by the skin is of the greatest importance and on it would appear to depend almost the whole of the response of the patient to the rays. Formerly most people looked on the skin as merely a protective covering, but its true importance to the body has been generally realised only since ultra-violet therapy came into prominence.

The functions of the skin are many and varied. By virtue of its tough horny layer it protects against external injury of both microbic and chemical nature. It plays a great part in the regulation of the temperature of the body, partly by means of the blood-vessels in the dermis and partly by means of the sweat secretion. When the temperature of the body tends to rise, the blood-vessels dilate and the skin becomes warmer. Heat is thus diffused into the surrounding atmosphere provided this has a lower temperature than the body. In addition to this diffusion of heat, the sweat glands are stimulated to secrete profusely and sensible perspiration occurs, the evaporation of this taking away heat from the body.

In addition to this temperature-regulating function, the sweat glands play an important part in the economy of the body by the excretion of deleterious products. If the kidneys are not functioning satisfactorily, the sweat glands take on this task and by their profuse secretion they help the body to get rid of noxious substances.

Talbert[31] found that the sweat secreted under the same environmental conditions had the same hydrogen-ion concentration whether the sweating was caused by

work or by heat. He found that there was a greater amount of ash in the sweat produced by heat than in the work sweat and that there was a greater amount of ash from the sweat of covered parts than from the sweat of uncovered parts. He also found that the parts of the body which eliminate the most acid, yield the smallest ash.

Leake[32] has determined that there is a substance which would seem to be citric acid in both the heat and the work sweat.

Sharlit and Scheer[33] have found that there is a mechanism in healthy skin for maintaining a constant pH of its surface.

The sweat glands also help in the lubrication of the skin and this function is most prominently displayed on the hands. No sebaceous glands are found on the palms, and here if anywhere thorough lubrication is necessary and this lubrication is carried out by the sweat glands.

Another function of the sweat glands is the maintenance of water balance. A large amount of water is given off by the skin through the sweat glands in the twenty-four hours in the form of insensible perspiration, and it has been calculated that a healthy man gives off as much as 40 grms. an hour is this way. Many factors govern this loss of water from the body, such as the amount and nature of the clothing, and the temperature and humidity of the atmosphere, but its importance is very definite as it is known that "water poisoning" occurs when a large amount of sweat is excreted and ordinary water only is taken to make good the loss. This effect is counteracted if salt is added to the liquid ingested.

The secretory function of the skin is shared by the sebaceous glands, which are found practically over all

the body, the palms and soles and the backs of the distal phalanges being the exceptions. The sebum lubricates the skin, tends to prevent loss of heat and moisture from the body, keeps the skin waterproof, so guarding against the effects of long continued action of moisture, and has a bactericidal effect.

Another function of the skin is that of absorption of substances applied to it. The absorption varies with the nature of the substance and the medium in which it is applied. Substances dissolved in water are not absorbed at all by the skin, alcoholic solutions are slightly absorbed, but greases and substances incorporated in them are absorbed, some of them freely. Gaseous and volatile substances are also absorbed by the skin.

Another important function is that dealing with sensation. The skin is richly supplied with nerves and, apart from ordinary tactile sensation, it is able to appreciate heat and cold and also pain. Various end-organs exist, such as Pacinian corpuscles, the corpuscles of Meissner, the corpuscles of Krause and Merkel's touch cells. The exact functions of these bodies are not accurately known.

Less important is the respiratory function of the skin. The amount of carbon dioxide and water exhaled through the skin is insignificant compared with that passing through the lungs, but in some of the lower animals the skin plays a very important part in respiration.

It now appears certain that the skin produces ferments, and according to several authors these are numerous in the skin. The best-known action of a ferment in the skin is that which has to do with the formation of pigment. Bloch[34] has shown that the cells which produce pigment are those of the basal

layer, and also the prickle layer when the reaction of the skin is intense. The pigment is formed by the action of an oxidising ferment elaborated by the cells of the basal layer on a substance brought to the cells by the blood-stream. He shows that the skin of albinos is without this ferment. This pigment manufacture may be hastened by various stimuli, such as X-rays and radium.

Less well-known are other functions of the skin—actual or potential. The reaction of the organism to different surroundings is brought about by the influence of the skin. It is more than likely that atmospheric conditions react on the skin. We all know how well we feel on a good day, and how miserable on a bad one. This is not merely a question of the ultra-violet rays from the sun, as we experience the same feelings even in mid-winter when we get little or no ultra-violet rays from the sun. May it not be that the barometric pressure or other atmospheric conditions have some bearing? We know that many animals presage the coming storm and anglers say that fish are not caught before a thunderstorm. We know also how people with rheumatism can frequently forecast a change in the weather and the coming of rain. It may be that the human skin is endowed with qualities similar to those possessed by animals, but that these properties are to a large extent lost as the result of our constant covering of the skin with clothing.

From the enumeration of its functions, it will thus be seen that the skin is a very important organ and it is more easily understood from this study of its many functions how easily its state of health may react on other organs of the body. The close connection between the skin and internal organs is shown by the alteration of the skin in visceral diseases. The dry

harsh skin of myxœdema is well known, as is the pigmentation in Addison's disease and the chloasma which is so frequently associated with uterine or ovarian disease. It has been suggested that the skin controls the balance of the endocrine glands, and it is interesting to note that the diseases mentioned above are diseases of these glands. Rollier[35] states that the skin is the most important source of immune bodies and is probably the most important endocrine gland in the body, and it may well be that it has an internal secretion of its own through which the beneficial effects of radiation are produced.

One of the most noticeable effects of a dose of ultra-violet rays is the production of an erythema of the skin, if the dose has been sufficiently large. As a rule the erythema may be observed from six to eight hours after the irradiation, although it may appear any time from four to twelve hours after exposure. The erythema will be more fully discussed in the chapter on Dosage.

According to Lewis and Zotterman,[36] the reaction of the cutaneous vessels consist of three parts, a local and active vaso-dilatation, a reflex dilatation of the muscular arterioles (little in evidence), and a locally increased permeability of the vessel walls.

The microscopic appearances of the red skin differ according to the dose which has been administered. A section of the skin taken twenty-four hours after irradiation shows that the changes are chiefly in the epidermis and especially in its deeper layers, in which œdema occurs, the intercellular spaces being widened and the cells spongioid. Mitotic cell division takes place, the granular layer disappears, and there is also a dilatation of the superficial vessels with an emigration of leucocytes into the deeper layers of the epidermis. If the reaction is more intense, the fluid poured out is

so great that vesicles form. There is cellular necrosis and crust formation attended by demarcating inflammation. The derma shares in the œdema and the fibres of the connective tissue become swollen and separated.

It has been found by screening that the rays which are responsible for the production of the erythema are between 3100 and 2800 Å.U. and these, as we have already seen, are the rays which are absorbed by protoplasm. This redness can be prevented if the part is smeared lightly with vaseline, as Peacock [37] has found that this substance stops the whole ultra-violet spectrum except a small band from 3800 to 3650 Å.U.

It has been stated that certain sections of the rays are antagonistic to each other while other bands are complementary to each other, but such contradictory results have been obtained that nothing definite can be said on the matter.

Coincident with the erythema, alterations of sensation are produced. As a rule there is merely itching, the intensity of which usually depends on the degree of the erythema. There may, however, be actual pain. If the erythema is intense, the discomfort may be so great that even the weight of the clothing is almost unbearable, while movement of the trunk is distinctly unpleasant. Occasionally the discomfort persists even after the redness passes off, and I have known one case in which the irritation became worse as the redness passed off and was at its height two days after all signs of erythema had disappeared.

Another effect of radiation on the skin is the production of pigmentation. Some writers say that this is caused by the erythema, but this is not the case, as one frequently sees pigmentation occurring without any erythema having been produced. This is notably the case in children, who redden with difficulty and yet

show definite pigmentation. The pigment granules are deposited in the deeper layers of the epidermis. The colour of the pigmentation varies largely with the colouring of the individual, being deeper in brunettes, but it also varies with the type of lamp used, being brown if the carbon arc is used, and somewhat greyish if the mercury vapour lamp is employed. It would appear that race also has a bearing on the pigmentation, the fairer nations not pigmenting so much as the darker Latin races.

The part played by the pigment is not known, but it can be definitely stated that it is not a protection against the ultra-violet rays. If it were, the pigmentation would be more intense with the lamp which gives rise to the greater intensity of ultra-violet rays, *i.e.* the mercury vapour lamp, but as has just been indicated, this is not the case. It may be that it is a defence against the light, as has been stated by Leonard Hill,[38] but more than this cannot at present be said.

It is a curious fact that the dorsal surface of the trunk as a rule pigments more deeply than the ventral, even though the patient is seated between two lamps and equidistant from them. No satisfactory explanation of this has been forthcoming, unless it is, as has been suggested, a reversion to ancient type, as it is well known that the ventral surface of animals is of a lighter colour than the dorsal.

It has been said that certain ultra-violet rays are responsible for the production of pigment, but marked pigmentation not infrequently occurs on the legs of people who sit much in front of a fire, chiefly elderly people. I have also seen marked pigmentation on the right side of each leg of a girl who had a gas fire to her right in the office in which she worked. As she was in the habit of sitting with her left leg forward

and her right slightly drawn back, the inner side of the left leg was pigmented and the outer side of the right leg. In these cases the pigmentation is due to heat and not to ultra-violet rays. As a similar pigmentation is obtained after X-ray treatment it would seem wrong to state that a particular band of ultra-violet rays is responsible for the pigmentation which is produced during treatment.

Other changes take place in the skin as the result of radiation. It is now well known that the ergosterol in the skin becomes activated to produce vitamin D. It is frequently stated that it is the cholesterol in the skin which produces this vitamin, but this can hardly be the case, as it has been shown that pure cholesterol cannot be activated by radiations. That this change takes place in the skin has been shown by feeding rats on a rickets-producing diet. If radiated skin is fed to them they do not develop rickets, but if non-irradiated skin be given, rickets is produced.

The temperature of the skin and subcutaneous tissues is definitely raised by radiation. Sonne[39] has shown that the luminous rays are chiefly responsible for this. They can heat the blood-carrying parts in and beneath the skin, without any feeling of scorching of the skin, to a temperature which is several degrees higher than the maximum temperature ever measured with fever, and about 6° C. higher than the temperature it is possible to obtain at the same depth by irradiating with the maximum bearable quantity of heat rays. He has also shown that guinea-pigs injected with an otherwise fatal dose of diphtheria toxin, were able to survive this dose if they were exposed after the injection for two hours to a light bath of visible rays. It may be, as he suggests, that this is due to the heat absorbed destroying the highly thermolabile toxin.

It may also be considered as certain that the formation of antitoxins can be promoted by such heating of the blood. This suggestion of the destruction of toxins is borne out by the fall of blood-pressure which is found to occur after radiation in pre-eclamptic cases (see page 165).

Haxthausen[40] has shown that a further change occurs in the skin. He found that if without irradiation the skin fat is removed with a wad of wool soaked with ether, the fat washed with ether and the latter evaporated, no effect will be observed on a photographic plate, or at all events only a very slight one. It is quite different with skin fat from a person who has been subjected to an irradiation. An undeniable effect on the sensitive plate will then be apparent. It may be this change, whatever its nature, which is responsible for the patient's skin giving rise after irradiation to an odour distinctly like that from a singed chicken.

The behaviour of the von Pirquet reaction shows that other definite changes occur in the skin as the result of exposure to ultra-violet rays. At the Skin Department of the Royal Infirmary, Edinburgh, in 1920 and subsequent years, this test was performed on a number of patients suffering from lupus, and attempts were made to correlate the results of the test with the type of bacillus as found by animal inoculation. After we began to give our patients general radiations, I continued to apply the Pirquet test to some of them at intervals. I was surprised to find that the result in one of the earlier cases was entirely negative, though previous to irradiation treatment being begun, the reaction to bovine tuberculin was very marked. Other similar cases followed. The first patient was unable to carry on with the treatment for business reasons, but about fifteen months after her last radiation, I performed

the Pirquet test again and the result was distinctly positive, as it had been at first. I then resumed the testing of other patients and found similar results. These results were discussed with one of my senior colleagues, Dr Cranston Low, who suggested that the antibodies were formed in the skin from which they were driven out by the radiations. The scope of the investigations was then extended and new patients who were sent to the Light Department, had the test performed on one arm. They were instructed to keep this arm covered with a bandage while the dose of radiations was being given. Some months later the Pirquet test was done on both arms. In some cases the reaction was negative on the arm which had been exposed during irradiation, and definitely positive on the arm which had been covered up. In other cases the reaction, while positive on the exposed arm, was distinctly less so than on the covered arm. This difference between the two arms was not due to any effect of the radiations on the tuberculin, as the patient was not permitted to go for treatment between the performing and the reading of the tests. It can only mean that there was a change in the skin. It may be, as Dr Low suggests, that the antibodies had been formed in the skin and driven out of it by the radiation and that therefore there was nothing to react with the tuberculin introduced in performing the test, while in the covered arm the antibodies had not been driven out and so a reaction was possible. If such be the case, it would suggest that it is the epidermis which is responsible for their formation. Whatever be the explanation, the result was quite definite, and it may be that the following up of this or similar reactions would give a clue to the nature of the action of ultra-violet rays.

Saidman[41] has investigated the photo-electric phenomena of the skin, and has shown that changes are produced in them by radiation.

In some cases there is a very definite reaction of the sweat glands to radiation, and patients who had not sweated at all or only with difficulty prior to radiation treatment, find that their sweat secretion becomes normal after treatment. The following case illustrates this clearly. A lady who was sent for treatment, had been resident in India for many years, and even there sweated with difficulty. When other people were sweating uncomfortably, she showed no sign of perspiration at all. On her return to this country this difficulty in sweating persisted. During the course of treatment she began to perspire freely and her sweat secretion has been normal ever since. She feels in better health, and this is doubtless due to her free perspiration.

That there is a very distinct **effect on the blood** as the result of irradiation has been shown by many observers, but very contradictory results have been obtained. These varying results are to a certain extent due to different observers making their investigations at different times after irradiation, and to the intensity and duration of radiation being different. There seems to be no doubt, however, that there is a definite stimulation of the hæmopoietic system. In practically all cases there is an *increase of the red cells* and also an *increase in the hæmoglobin*, and the latter may remain above the normal for a considerable time after the treatment has ceased.

There would seem to be considerable *variations in the leucocyte count.* Tosi[42] found that there was a leucocytosis immediately after irradiation, then a leucopœnia from half to one hour later, and that was

followed from six to twenty-four hours later by a second phase of leucocytosis. Other observers have found no change in the white cell count.

Similar variations are found in the *differential count.* Polymorphs are sometimes increased, sometimes diminished, and the same is found with the lymphocytes. Some writers state that there is usually an increase in the polymorphs with a decrease of the lymphocytes, while others state that the reverse is the case. It will thus be seen that there is considerable difference of opinion as to the effect of radiations on these two types of white cell, but all observers would appear to agree that there is an increase in the number of eosinophiles.

Clark [43] found that the ultra-violet rays shorter than 3000 Å.U. induced a great increase of lymphocytes while the polymorphs remained constant. On the other hand the near ultra-violet rays just short of the visible spectrum had a depressing effect on the lymphocytes and gave rise to an increase in neutrophiles lasting only a few hours and followed by an abnormal decrease.

The number of *blood platelets* is also increased.

Regeneration of the blood rapidly occurs after bleeding. Hobert [44] found that after bleeding with loss of 50 per cent. of the red cells regeneration was complete in thirteen to fourteen days with exposure to light.

Mayerson and Laurens [45] found that changes in the *volume of the plasma* also occurred. After an individual exposure there was a temporary increase in the plasma, but there was a return to normal within a few hours. This increase in the plasma occurred again, but was not augmented by further exposures, its duration depending on the strength of dosage and the interval between exposures.

A very definite effect on the blood is the *increase of the bactericidal power.* This has been investigated by

Colebrook, Eidinow and Hill,[46] who found that the increase was greatest following an erythema dose, though more recently Eidinow[47] has shown that it occurs, although to a less marked extent, following a dose short of that producing redness. The latter observer[48] found that this increased bactericidal power must be due to changes which develop with the circulation of the blood through the radiated area. The blood from a radiated limb was found to have an increased bactericidal power while that from an non-radiated limb was unchanged. If too big a dose is given there is a decrease in the bactericidal power. Radiation in acute illnesses tends to diminish this property, and this makes the dosage in acute illnesses a matter of great importance. The bactericidal power is not due to any change in the fluid but seems to be definitely invested in the leucocytes.

These changes in the blood do not exhaust the list of those that occur. It is now well known that the *concentration of calcium* and the *inorganic phosphorus* is increased as the result of radiations and that the blood clots more rapidly. The latter may be partly due to the increased calcium content and partly to the augmentation of the number of platelets.

Leenhardt and Chaptal[49] investigated the *alkalinity of the blood* and found that under the influence of the ultra-violet rays the alkaline reserve increases constantly and rapidly, but not always in proportion to the time of exposure. In normal children it tends to reach the adult value.

Rothman, Pincussen, Bloch and Faber have shown that there is a diminution in the amount of *blood sugar* following radiations. The latter observers[50] found that the excretion in the urine was not increased and there was no evidence to show that the blood sugar had been

deposited in the tissues, and they conclude that the pancreas had been stimulated by the ultra-violet rays to turn out more insulin.

Laqueur and Wiener[51] found the same decrease in the blood sugar after the radiation of the mucous membranes of the mouth and vagina as after general radiations.

The tyrosin in the blood at first increases but falls when pigmentation develops.

Far-reaching effects in **other organs** are observed as the result of radiations. There is a definite effect on the suprarenals which are depressed, resulting in a fall of blood-pressure. It has also been shown by animal experiments that the weight of all the *endocrine glands* and the testes increases as the result of radiation, the greatest increase being found in the parathyroids.[52]

In addition to these changes, there are others that occur though of a more general nature. It has been found that moderate doses improve the *carbohydrate metabolism* as evidenced by the glycæmic curve after the administration of carbohydrates.

Bierry[53] found that ultra-violet rays acted on carbohydrates in a way analogous to the action of a soluble ferment. The production of gases resembles that induced by yeasts. Thus may be produced an actual ultra-violet fermentation.

Ferri[54] investigated the effects of radiations on the *nitrogen metabolism* in children of from four to seven years of age who were in good nutritional condition. They were kept on a rigorously fixed diet both qualitatively and quantitatively during the period of observation. In children less intensively radiated the results demonstrated that the organism may be stimulated so as to retain and fix a larger quantity of nitrogen introduced with the food. In children radiated

more intensively it became evident that the retention of nitrogen by the organism tended, during the period of radiation, to diminish in the same proportion as the quantity of nitrogen eliminated by the urine increases, which shows the possibility of inducing an acceleration of nitrogen exchange.

Respirations become slower and deeper as the result of radiations.

Argyll Campbell [55] working with some of Sequeira's patients at the London Hospital, found that there is no change in the *basal metabolism.*

Radiations have a very definite effect on the *nervous system.* Mental processes are stimulated, and children undergoing steady radiation treatment are more intelligent than town children of the same age as has been shown by Gauvain. The outlook is brighter and there is a definite feeling of invigoration and well-being. In addition there is a definite analgesic effect.

CHAPTER V

THEORIES OF ACTION. PATHOLOGICAL EFFECTS OF LIGHT

Theories of Pincussen, Rothman, and Jesionek. Pigmentation Theory. Sonne's Explanation. Psychic Theory of Action. Counter-Irritation Explanation of Action. Xeroderma Pigmentosum. Hydroa Vacciniforme. Summer Prurigo. Pellagra. Sensitisation due to Buckwheat and other Substances. Snow Blindness.

VARIOUS theories have been put forward to explain the action of ultra-violet rays. Pincussen[56] believes that the direct action of the rays is one that is detrimental to practically all processes of life; fermentation processes are retarded, and under a sufficient irradiation of the live cells these will die. Notwithstanding this, some effects exceedingly favourable to the organism may be produced. He supposes that by the rays killing the superficial cells of the skin, ferments or similar substances are liberated from these cells and can be subsequently absorbed by the organism and be of benefit to it.

Rothman[57] states that the indirect action of the light is transmitted to the interior of the body through the agency of the involuntary nervous system, and that light baths bring about a condition corresponding to sympathetic depression (sympathetico-hypotonia). Blood-pressure and blood sugar are reduced and sugar tolerance is lowered.

Jesionek[58] believes that the effect of light on the sympathetic nerves of the superficial vessels is brought

about by the agency of the basal cells. These cells absorb light and either themselves secrete substances which have a paralysing effect on the sympathetic, or there exists between it and the basal cells a far closer anatomical relationship than has been thought possible.

Rollier [59] accepts as plausible that the light absorbed by the blood makes it a reservoir of radiant energy which activates oxidation and reduction processes.

It has been suggested that the benefit is due to the increased bactericidal power of the blood, but this explanation is hardly sufficient. The bactericidal power is chiefly developed when an erythema is produced, and many patients show steady progress without any erythema.

Pigmentation has been said to have a definite effect in bringing about the beneficial results of radiation, but again this explanation is not satisfying as patients frequently improve steadily without any pigmentation, while other cases even when deeply pigmented, show steady advance of the disease. If the presence of pigmentation is of itself beneficial, how does one explain the presence of pigmentation in diseases such as chloasma or Addison's disease in which the pigmentation is present as part of the disease picture?

Sonne [60] attributes the curative effect to the heating of a large part of the total blood volume to a temperature possibly exceeding the highest reached in fever, without heating the rest of the body to any appreciable degree. He believes that the long-continued elevation of the body temperature gives rise to the production of antibodies.

Some writers have suggested that the effect of the radiations is chiefly psychic, but those who make such a statement have little experience or knowledge of ultra-violet ray therapy. The long list of chemical

changes indicated in the previous chapter surely shows the profound influence which the rays have on the body, but apart from these changes, clinical experience furnishes abundant proof that ultra-violet rays do not act through psychic means. In some cases there is no doubt that the psychic element does exist, but in such patients most remedies work through psychic means, but these cases are in the minority and other cases prove definitely how small a part the psychic factor plays. When a patient comes for treatment for, say, neuritis, benefit is expected from the treatment, and if the remedy were chiefly psychological in its action, such benefit would show at once. Instead of that we find that neuritis, as a rule, gets much worse for forty-eight hours after the commencement of treatment. Again, how can the psychic effect explain the benefit of treatment in infants? I have treated a considerable number of children under one year, my youngest patient being only four and a half weeks old. The mother, an ordinary working-class woman, noticed the difference in the child's appearance after only two exposures, and remarked how pink the child's lips and gums were compared with their blue appearance before the treatment was begun. The improvement continued and after seven days there was a feeling of some substance in the fold of the skin taken up between the fingers. Surely it is obvious that such changes were not due to psychic effect in an infant of that age. Such examples could be multiplied, and I am sure that all serious workers could quote others, but sufficient has been said to show that only ignorance could suggest that the effect of ultra-violet rays is chiefly psychic. It is interesting in this respect to note that the Scottish Board of Health[61] states that suggestion is seldom so universally successful.

It has been suggested that the effect of ultra-violet rays is similar to that produced by the application of a mustard plaster. In a Report published in the early part of 1929 by the Medical Research Council it is stated[62] that the same effects follow inflammation inflicted by heat or other irritants than light, and that there is no present reason to suppose that artificial light can do more in this way than a mustard plaster. A responsible medical journal[63] stated in a leading article some months earlier than the publication of the Report indicated, that "It is by no means determined yet whether the beneficial results in some cases of rheumatoid arthritis, neuritis, and sciatica are not merely due to a counter-irritation of the same order as that produced by a mustard plaster." It is, in my opinion, quite erroneous to liken the effect of radiations in these conditions to that of a mustard plaster; the effect is systemic, not local. Some years before the statement appeared in the journal referred to, I had treated a lady for debility following an operation. She had had sciatica for many years, and no cause had been found for it. For the first two days after she began treatment the sciatica was much worse, but by the end of the first week it had almost entirely gone. She received three weeks' treatment altogether, and apart from a slight recurrence the following spring, which cleared up readily after a few doses of radiations, she has been free from her sciatica since. As the treatment was general and not local, and given with the patient seated, the effect could not have been due to counter-irritation like that produced by a mustard plaster. It must have been systemic. It is perhaps unfortunate that most practitioners have given local radiations for such a condition, as in this way the mistake has probably arisen that the effect is due to counter-irritation. When

the hip-joints are affected in rheumatoid arthritis and the patient gets treatment to the general surface of the body, no radiations reach the skin over the hip-joints by reason of the garment worn during treatment, and any effect on these joints must therefore be systemic and not due to counter-irritation.

It has been suggested that the action of the light on one part of the body produces a fluorescence in the blood-stream which is carried to or produces a fluorescence deep within an unilluminated part of the body. This is quite unacceptable as fluorescence is a phenomenon which occurs only at the point at which the object is irradiated and only as long as the stimulus is acting, and it ceases immediately the light stimulus is cut off.

It must be admitted that there has been no adequate explanation brought forward of the way in which ultra-violet rays act. Too little is known of the chemistry of the body in health and disease to allow one to recognise minute variations, and little or nothing is known of the action of the rays on the various layers of the skin. The suggestion has been made that the chemical changes responsible for the beneficial effects occur in the horny layer, but it is difficult to see how this can be, as the cells of this layer are dead. Whatever the action may be, whether photo-electric or chemical in nature, it is practically certain that it occurs in the deeper layers of the epidermis and in the true skin, and it is only by patient investigation and observation, and the recording of carefully observed facts that progress will be made in deciding how the rays act.

It must not be forgotten that the action of light may be harmful instead of beneficial. Ordinary sunlight may produce certain diseases in susceptible

persons, while other people can be sensitised by the administration of certain substances. The diseases which can be produced in people susceptible to light are xeroderma pigmentosum, hydroa vacciniforme, and summer prurigo.

Xeroderma Pigmentosum is a very rare skin disease which tends to affect all the members of one sex in a family. It begins when the child commences to run about in the open air, and shows merely as a roughness of the skin of the exposed parts. Later, pigmented spots appear and the skin commences to atrophy, and then dilatation of the capillary vessels occurs. The next development is the appearance of little warty growths, and if these are not treated they tend to take on a cancerous growth which ulcerates and destroys all the tissues in the neighbourhood. As a rule, these children, even though protected from the sun, die before adolescence is reached.

Hydroa Vacciniforme is for the most part found on the exposed parts, especially the nose, cheeks and ears, and hands and lower parts of the forearms. The disease as a rule affects children, beginning about the age of three or four, but occasionally it commences in adult life. The eruption appears in spring or early summer and disappears with the coming of autumn. It is of a vesicular nature, but often the lesions begin as red spots on which vesicles develop subsequently. They vary in size and there is in most of the lesions a central depression or umbilication. Several of the vesicles may coalesce to form bullæ. The lesions dry up, forming a crust which drops off after a variable interval to leave a scar which is at first red, but later becomes white. The scarring is permanent. The disease continues to come and go till adolescence is reached when it finally disappears.

The eruption as a rule appears on the exposed parts only, though I have seen it on the legs and feet of a girl. It was interesting in this case to note that it was present on the dorsum of both feet where the shoe was open, was not present under the strap of the shoe and reappeared immediately above the strap.

McCall Anderson [64] of Glasgow pointed out, in 1898, that the urine in some of these cases contained hæmatoporphyrin, and this opinion expressed so many years ago is especially interesting in view of the more recent knowledge that hæmatoporphyrin and allied substances can provoke sensitisation to light.

Summer Prurigo is a condition allied to hydroa vacciniforme. It appears on the exposed parts and behaves as does hydroa vacciniforme, appearing in spring and disappearing in autumn, to re-appear the following spring and so on till adult life is reached, when it tends to disappear finally. The eruption is papular and there is less tendency to grouping than in the former disease.

Cases of **Urticaria** due to the sun's rays have been recorded.

Pellagra is another condition in which the skin is sensitised to light as the result of some toxin circulating in the blood.

These conditions are due to a sensitiveness to light, the cause of which is not definitely known. Probably allied to these are the "permanent freckles" described by Sequeira and the "war melanosis" described by Riehl. In other cases the sensitiveness is due to a substance which is known. In America a form of sensitisation to light occurs which is due to the ingestion of buckwheat, and it is possible that hydroa vacciniforme and summer prurigo are due to sensitisation to a wheat protein.

The case of Meyer-Betz is frequently quoted as showing the sensitisation to light brought about by certain substances. He injected hæmatoporphyrin into himself and on exposure to light his face and hands became markedly swollen.

Other substances such as eosin when painted on a part render it more sensitive to light, and care should be taken in radiating patients who are using such substances lest a violent reaction be produced.

It is well known that Alpine climbers and Arctic explorers not infrequently suffer from snow blindness. This is due to the intense reflection of ultra-violet rays from the snow and ice. In the industrial field, acetylene and arc welders occasionally suffer from eye trouble if they do not take adequate precautions to protect themselves.

CHAPTER VI

APPARATUS

Carbon Arc Lamps. Irregularities in Burning. Carbons. Mercury Vapour Lamps. Atmospheric or Vacuum Type. Irregularities in Burning. Carbon Arc *versus* Mercury Vapour Lamp. Advantages and Disadvantages of each. Heating and Ventilation of Treatment Room. Colour and Finish of Walls. The Installation. Goggles. Couch.

THERE is no doubt that natural sunshine is the best form of treatment, but unfortunately in Britain the climate as a rule does not permit it to be used extensively. Again, the inhabitants of towns cannot make much use of such sunshine as is available and we are compelled, therefore, to make use of electrical apparatus for the artificial production of the beneficial rays. The two types of apparatus which can be employed are the carbon arc lamp and the mercury vapour lamp.

The modern **arc lamp** for therapeutic purposes is one in which the arc is automatically regulated. In its simplest form it is one in which, when the current is switched on with the carbons in contact, the circuit is completed through a coil which then acts as an electro-magnet. This attracts a core, to the other end of which either the carbon itself is attached or a more elaborate arrangement for holding the carbon. The movement of the core thus separates the carbons and the arc is struck. When the arc breaks, the magnet ceases to attract the core which then falls, the carbons

again coming into contact and so completing anew the circuit, when the arc is again struck.

Many different types of arc lamps are now on the market, but they vary merely in detail, some being more elaborate than others and more complicated, but the basic principle in all is essentially that described above. All these varieties are fully described and illustrated in the catalogues of the various firms which sell electro-medical apparatus, and a detailed description of the various lamps is out of place here.

In some varieties of lamps, *e.g.*, the tungsten arc lamp, the automatic regulation described above does not exist and the arc is controlled by hand. This is not so satisfactory as the automatic control.

The arc may be closed or open, but as the enclosing globe must be of quartz to allow of appreciable radiation getting through, such an apparatus of any considerable size and power would be very expensive. The only advantage the enclosed arc has, is that the carbons do not burn away so quickly, but it is doubtful if this advantage is commensurate with the disadvantages of such a lamp, and it is the open arc lamp which will be considered here.

Arc lamps differ considerably in their power, some on the market consuming only 5 amperes and others 50 or even 75 amperes. The smaller amperage lamps are not satisfactory, because of the small output of ultra-violet rays. This means that a correspondingly longer exposure must be given before satisfactory results are obtained, and a long exposure is irksome both for the patient and the operator. Personally, I do not favour greatly the very high-powered lamps. The greater the amperage the greater is the amount of heat at a given distance. When a great heat is given off, the patients tend to find it uncomfortable to

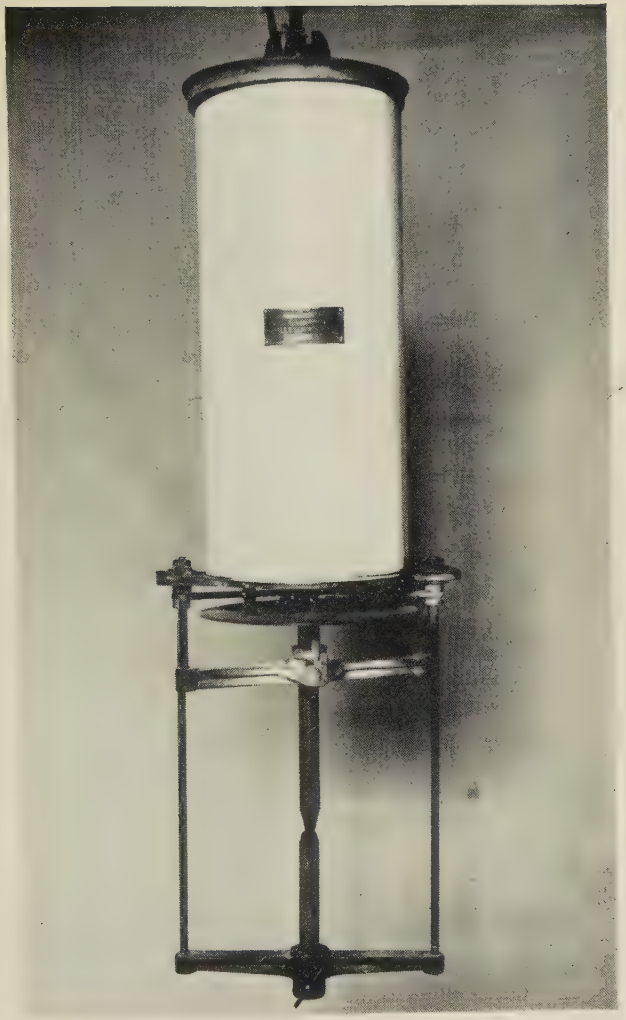

FIG. 2.—Westminster 20-Ampere Lamp.

sit at a distance of, say, 3 feet. To sit in comfort the distance between the lamp and the patient must be increased, and this means a marked diminution in the amount of ultra-violet rays received by the patient, as will be at once seen from the consideration of the law of the inverse square (see page 74). To compensate for this a longer exposure must be given and so the apparent gain in time by using a high-powered lamp is not realised.

The medium-powered lamps of from 20 to 30 amperes are to my mind the most satisfactory, and I have been using for some years, both in hospital and private work, the 20 ampere lamps manufactured by the Westminster Engineering Company, Ltd. The general appearance of the lamp is shown in Fig. 2, and the mechanism in Fig. 3. These lamps have given every satisfaction in dermatological, medical, and surgical cases.

With all varieties of arc lamps a suitable resistance and control board are required, and an ammeter in the circuit is essential. The firms who manufacture the various types of lamps, usually make a control board also to suit their apparatus, and it is advisable to obtain both lamps and accessories from the same maker, as the standard resistance supplied by one manufacturer may not without alteration suit the lamps sold by another.

When the carbons are of different diameter, the larger is the positive pole, as the positive carbon burns more rapidly than the negative, which can therefore be smaller. When the current supplied is direct, the positive carbon becomes much hotter than the negative. A crater forms at the end of the positive and this glows intensely when the lamp has been on for a few minutes. The crater tends to throw the rays downwards and so the lamp should be rather higher than

the part to be irradiated. If the carbons are of the same diameter this crater forms when the arc is a short one, but with the long flame arc the crater is hardly formed at all, the flame rising all round the carbon and giving rise rather to an inverted cone, somewhat rounded at the point. The rays from such an arc are not thrown downwards and so the lamp should be on a level with the part to be treated.

It has been suggested that a greater output of ultra-violet rays is obtained if the lower carbon is made the positive one, and that less time will consequently be required for the dose to be given. I have tried this arrangement and found that the lamps burned much less steadily, and so I had to revert to the original position with the upper carbon positive. Even if the lamps burned steadily, it is difficult to see what advantage is to be gained, if the carbons are of different diameter at all events. With the formation of the crater in the larger positive carbon the rays would be thrown well up, and a considerable proportion of the beam of rays would tend to be lost by being thrown against the upper and bulkier portion of the lamp.

Carbon arc lamps burn more satisfactorily on direct current. If alternating current is supplied, a choke coil must be inserted in the circuit. The carbons in the case of alternating current supply are of the same temperature and the output of ultra-violet rays is reduced.

The poles are more important than the flame in the production of the visible rays, but the flame gives the greater proportion of the effective ultra-violet rays. Investigations by Griffiths and Jack[65] show that when the watts consumed in the arc are kept constant, lengthening of the arc produces a greater ultra-violet emission. The longer the arc consistent with stability,

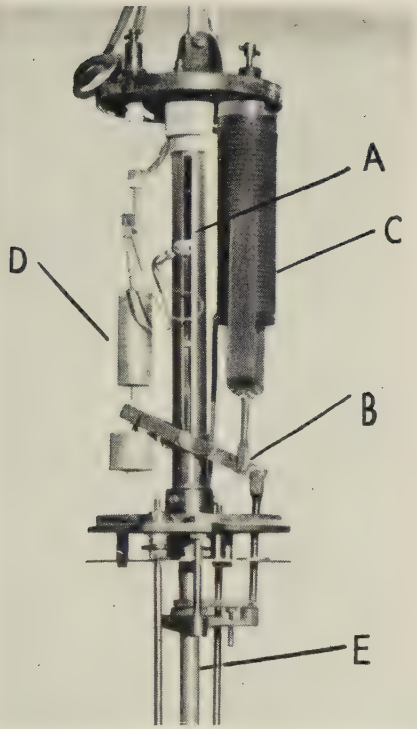

FIG. 3.—Mechanism of Westminster 20-Ampere Lamp.

A. Guide for carbon holder.
B. Mechanism for lifting carbon.
C. Coil.
D. Dash-pot.
E. Positive carbon.

the greater is the ultra-violet output. The higher the voltage and the higher the amperage, the greater also is the ultra-violet emission.

The type of radiation emitted depends on the positive carbon more than on the negative one. If a cored carbon is used in conjunction with a plain one, the cored carbon ought to be the positive pole, otherwise the ultra-violet emission is little more than that obtained by using plain carbons.

Ordinarily the arc lamps burn very steadily and give little trouble, but there are some points about their working which it may be helpful to mention. If the carbons are not kept at a fixed distance by a special mechanism, the gap between them becomes steadily greater, the voltage across the arc rises and the amperage passing through the lamp diminishes. After the lamp has been burning for some time, the gap between the carbons becomes too great for the current to span. The lamps then go out, but the arc is automatically struck again and the lamps light up again without delay. If they do not, switch off the current and examine the carbons. It may then be found that the carbons are not making contact. If they are too short they will have to be renewed, but care must be taken in handling them on account of their heat. An old pair of thick leather gloves will be found most useful for changing the carbons. Apart from preventing the hands from being burned, they prevent them becoming soiled. If the carbons are long enough and yet have not come in contact, the guide parts require cleaning as they will be found to be covered with deposit from the ash of the carbons.

Sometimes the lamps will not light up when the current is switched on. Switch off the current before approaching the lamps. The carbons may not be in

contact because they are too short as the result of previous use, or because the upper one has not fallen properly for the reasons given above. The remedy in each case is as is indicated in the preceding paragraph. At other times, however, the carbons are apparently in contact and yet the arc does not strike. In these circumstances the upper carbon should be moved up and down after the current has been switched off. It may be that the guides are dirty, but at times a small solid piece of burnt carbon remains between the two carbons. This falls out when the upper carbon is lifted and the arc should then strike when the current is switched on. Before examining the lamps, however, it is advisable to see that the wall switch is in the "on" position. If it is not, it is obvious that no current can pass to the lamps even when the control board switch is closed. It is surprising how frequently this happens. Only after this has been examined should one pass to examine the apparatus itself.

If dirty guides are the cause of the lamp not working properly, an early opportunity should be taken to clean the guides and the dash-pot when there is one. To prevent faulty working from this cause, the lamps should be cleaned regularly with a small brush, and the dash-pot taken out occasionally and the interior cleaned with paraffin. A dirty dash-pot may be the cause of the carbons not separating as they should when the arc is struck.

Many different varieties of **carbons** are on the market, and each maker gives, as a rule, a wide choice of many types. Carbons may be pure, or they may be impregnated with various substances such as iron, tungsten, cerium, nickel, copper, aluminium, etc. Pure tungsten carbons may be obtained, but the lamps for their use are not usually fitted with an automatic

regulating device and the carbons have to be fed by hand. In addition to this disadvantage, the fumes are distinctly troublesome and the carbons do not, as a rule, burn steadily, but splutter and throw out sparks. Another disadvantage of tungsten carbons is their cost.

In deciding which type of carbon is to be used, the spectra of the different varieties ought to be studied, and the manufacturers, as a rule, have charts giving the different spectra of the various types of carbons which they make. For reasons which are given subsequently (see p. 62) it is advisable to avoid carbons giving a large proportion of rays of short wave-length, and the choice should rather fall on those which emphasise the spectrum in the neighbourhood of 3000 Å.U. and above rather than below it. These charts of the various spectra are not to be relied upon implicitly, as it is quite possible by altering the length of exposure and the width of the slit through which the beam of light passes in making the photograph, to alter the appearance of the spectrograph. At the same time they serve to indicate which carbons have a large proportion of the shorter wave-lengths.

Even when the type of carbon to be used has been decided upon, there are other factors which ought to be taken into consideration. Some varieties burn steadily, others splutter and spit and tend to throw out a shower of sparks periodically. This is a bad fault as it tends to frighten nervous patients and children, and may even burn them, while in private work it has a disastrous effect on a carpet, the sparks frequently going far beyond any tray which may be placed beneath to catch the ash from the carbons. Some carbons, again, give rise to more pungent fumes than do others, and this becomes disagreeable both

for the patient and the operator. Personally, I prefer a white flame carbon emphasising the spectrum as indicated above. The most satisfactory carbons I have ever used were of Austrian manufacture. They burned steadily and quietly, the fumes were not noticeable, and they gave rise to a fine deposit of ash. Unfortunately they do not seem to be procurable now. The next best that I have found are Siemens' White Flame or Conradty's Noris Chromo Brilliant White. From these varieties I have had excellent results in dermatological, medical, and surgical work. I have tried other varieties of the same manufacturers' carbons and also several varieties of General Electric and Sunic manufacture, but I have not found them so satisfactory as the types I have indicated. Of course, this is simply my personal experience, and other workers may prefer some of the varieties which I have not found satisfactory for one or other of the reasons given above.

If for any special purpose a more irritating effect is desired, *e.g.*, in the treatment of alopecia areata, a carbon which contains a larger proportion of rays of short wave-length could be chosen.

Mercury vapour lamps are quite different from the carbon arc in their construction. The essential principle in all the different varieties is that the arc is struck when a column of mercury in a quartz tube is broken. In one of the earliest types for therapeutic purposes, the Kromayer, the mercury was contained in the two limbs of an inverted U of quartz. A single column of mercury was obtained by tilting the tube so that the mercury in each limb flowed towards the bend. When contact was established, the column was broken by bringing the tube back to its original position, and the arc was then struck. My earliest experience in ultra-violet therapy was gained with this lamp in

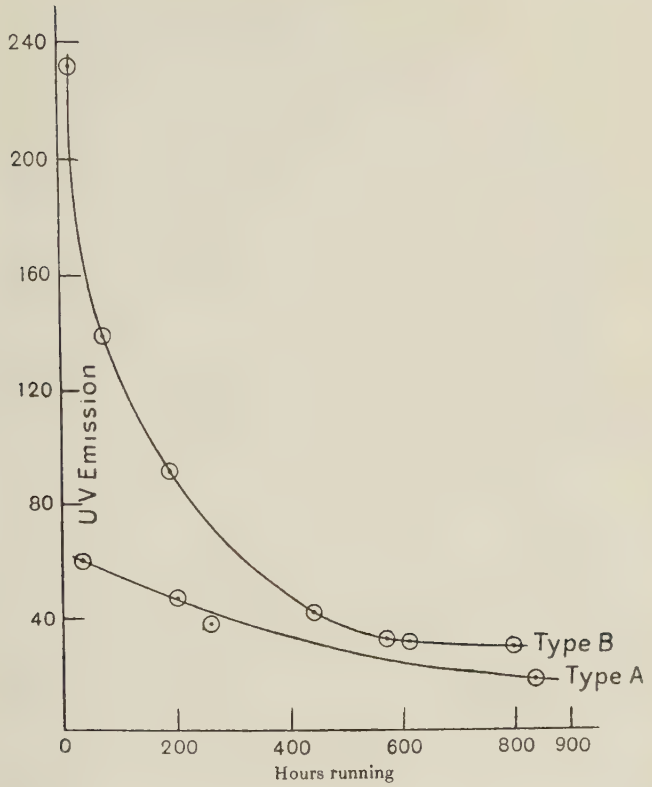

FIG. 4.—Deterioration of Mercury Vapour Lamps with use.

Type A. Atmospheric Lamp.
Type B. Vacuum Lamp.

Reproduced by permission from Reports of Medical Officer of Health, Aberdeen, 1925.

pre-war days, and I can testify to its value in treating patches of lupus vulgaris by pressing the lamp against the diseased part.

Many modifications of this lamp are now available, though the water-cooled Kromayer is still on the market. Most of the lamps, however, are now air-cooled. In many of the lamps at present available the arc is struck by tilting, though the quartz tube is no longer the shape of an inverted U. In one lamp the column of mercury is broken by a heating device at one end of the tube.

Mercury vapour lamps are of two types, one where the arc burns in a vacuum and the other where it burns at atmospheric pressure. The vacuum type has the distinct disadvantage of the hammer action of the column of mercury when the lamp is moved, and the quartz tube is liable to be broken unless the lamp is moved with great care. The atmospheric burner is free from this disadvantage. The initial output of ultra-violet rays is greater from the vacuum lamp than from the atmospheric type, but it falls off more rapidly as the burner ages. Tests have been carried out which indicate that the intensity of the vacuum lamp is reduced from 230 units to 40 units after the lamp has been burning for 400 hours. The atmospheric type deteriorates less rapidly and more regularly, the reduction being from 60 to 30 units in 400 hours. The accompanying Chart (Fig. 4) shows this deterioration, and it will at once be seen how great must be the difficulty in regulating the dose with the vacuum lamp when it is new. In fact, dosage with the vacuum lamp must to a large extent be merely haphazard when the lamp is comparatively new. Apart from other advantages it would therefore appear that the atmospheric type is the more satisfactory variety of

mercury vapour lamp. Figure 5 illustrates the direct current model manufactured by the Kelvin, Bottomley and Baird Company. The burner for this model is shown in Fig. 6, while in Fig. 7 is shown the arrangement of the circuit and heating coil. The whole of the quartz tube below and beyond CD is filled with mercury. At A and B an electrode projects into the mercury. When the current is switched on, its path through the burner is from electrode A through the mercury to electrode B, thence through the heating coil E and out to the negative terminal. The heater E vapourises a little of the mercury in the tube, and the arc is struck, ultimately filling the whole arc tube. On switching off the current the mercury automatically re-enters the arc tube ready for lighting again. In an earlier model the heating circuit was automatically cut out soon after the arc was struck, but now it remains in the main circuit as by this arrangement the quartz tube is considerably simplified.

When alternating current is supplied the burner is different, being the shape of an open V.

A mercury vapour lamp is not ready for use as soon as it is switched on, but must be allowed to remain on for at least five minutes before treatment is commenced, as the output of rays is slight to begin with and increases in intensity as the lamp becomes warmed up.

A hood is always supplied with a mercury vapour lamp, and in some models the hood can be closed and localisers can be fitted to allow of treating small areas. In the model illustrated instead of fitting another hemispherical part the hood shown is simply reversed, so that the open part is away from the patient and the variously sized applicators are simply fitted to an opening in the hood. This is a distinct advantage as it

FIG. 5.—Kelvin, Bottomley and Baird Mercury Vapour Lamp. Heliorite D.C. Model.

prevents the lamp becoming overheated, a not infrequent cause of irregular burning of mercury vapour lamps.

In using the mercury vapour lamp great care must be taken to see that the terminals are properly connected, as the lamp would speedily be destroyed if the polarity were not correct. Mercury vapour lamps are rather uncertain in their action. Not infrequently they go out after they have been burning for some time, especially if the hood be in position for treating small areas by means of one or other of the applicators. This is due to the lamp becoming too hot, and the lamp must be allowed to cool down before the arc can be struck again. This fault is specially noticeable in the smaller type of mercury vapour lamp. Movement of the lamp while it is lighted is often sufficient to cause it to go out. Even slight vibration of the floor in the neighbourhood of the lamp is frequently sufficient to put it out.

If the mercury vapour lamp does not light up when the current is switched on, the wall switch ought to be examined, and if it is in the "on" position, attention must then be directed to the lamp terminals.

Burners ought to be cleaned from time to time by means of a pad of cotton-wool moistened with pure alcohol.

There is no doubt that the carbon arc lamp is much superior to the mercury vapour lamp. All observers who have had the greatest experience, favour the carbon arc. Gauvain [66] states that the mercury vapour lamp is a long way behind the carbon arc. Sequeira [67] agrees with this and adds that it has a more limited field of usefulness. Strandberg [68] states that the mercury vapour lamp is usable, but the same good results must not be expected as from the carbon arc, and the period of treatment will take longer.

One reason for the superiority of the carbon arc is the presence of the heat and light rays. It seems to be definitely proved that these rays enhance the effect of the ultra-violet rays, as is the opinion of Bernhard, Rollier, Sonne and others. The mercury vapour lamp is deficient in these rays, and to supply them the manufacturers of these lamps advise the use of a powerful light bulb in conjunction with the lamp. It seems inadvisable, however, to multiply pieces of apparatus when one lamp can be obtained which will supply all that is necessary in treatment. Even though a powerful light bulb is employed with a mercury vapour lamp, that does not eliminate the large amount of short irritating rays produced by the mercury vapour lamp. These limit the exposure which can be given, and consequently the benefit that is obtained. If a filter is employed to cut out these rays so that a longer exposure may be given, it does away with what is supposed to be one of the chief advantages of the mercury vapour lamp, viz., the short time required for treatment. All these devices appear to me to be only a tacit recognition by the manufacturers of the inferiority of the mercury vapour lamp and an attempt to approximate it to the carbon arc.

There is really nothing the mercury vapour lamp can do that cannot be done equally if not more satisfactorily by the carbon arc, provided the right type of carbon be chosen. Two exceptions to this general statement are to be made; in cases of acute illnesses where the mercury vapour lamp is of use on account of its portability, and in direct radiation of the eye, where the heat rays from the carbon arc would have a deleterious effect on the lens.

A study of the spectra of the various sources of radiation helps to make it clear why the carbon arc is

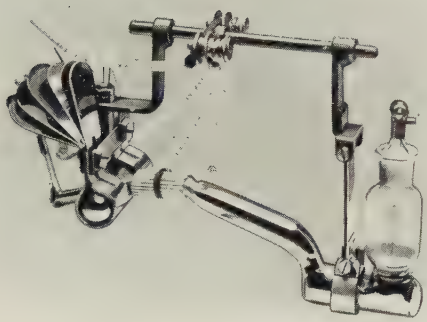

FIG. 6.—Burner of K.B.B. Lamp.

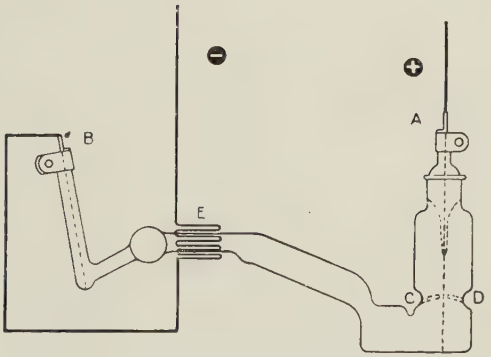

FIG. 7.—Diagram of Circuit and Heating Coil. K.B.B. Lamp.

so much superior to the mercury vapour lamp. It is generally admitted that the solar radiation is the best form of treatment where it can be obtained. The solar spectrum is a continuous one and shows no rays below the 2900 Å.U. level. The shorter rays are filtered out by the soot and smoke of the atmosphere so that few rays less than 3000 Å.U. are actually available. There is, however, a definite increase in the amount of energy when the 3130 Å.U. wave-length is reached, and it is greatest between 4000 and 5000 Å.U. There is thus a considerable amount of the long ultra-violet rays, and also of heat and light rays in the solar spectrum. The spectrum from the mercury vapour lamp, on the other hand, is essentially a line spectrum with a few heavy lines at the inner ultra-violet and violet end, but primarily effective in the shorter ultra-violet rays, while the tungsten and iron spectra are even more unfavourable in that respect than is the mercury vapour lamp. All of these three are thus seen to give a very large proportion of short rays, and these rays do not penetrate the outer layers of the skin and consequently represent — from the therapeutic point of view — wasted energy. The carbon arc gives a continuous spectrum with a distribution of energy more akin to that of the sun, though not identical with it. It is therefore the light which most nearly approaches sunlight and it seems reasonable that it should be the best substitute when the solar radiation is not available. In the event of something rather different being desired, a source of radiation which emphasises the spectrum in the neighbourhood of the solar spectrum is preferable to one which gives a large amount of rays to which the body is not ordinarily subjected, and indeed from which it is specially protected by the ozone in the atmosphere.

Spectra from different sources are shown in Fig. 8. For these spectrographs I am indebted to Professor Barkla and Dr Milne of the Physics Department of the University.

The beneficial effects of carbon arc radiation as opposed to the effect of the mercury vapour lamp is shown not only by clinical results, but also by the effect on plants. E. and W. Kerr Russell [69] show that the exposure of seedlings to a mercury vapour lamp is detrimental to their growth, and they state that presumably the rays of short wave-length are responsible for this effect. The effect of the carbon arc light on plants is quite different. For some winters past I have experimented with bulbs, some pots getting radiations and others being screened from the lamps. All the pots were kept in the same room so that the effects of temperature, light, etc., were the same in both cases. The radiated bulbs grew more rapidly than the non-radiated and had a healthier appearance, while the flowers not only appeared earlier, but lasted longer than the non-radiated ones. This has happened each time I have tested it, and this experiment shows that the carbon arc light, so far from being detrimental to plant life, as is the mercury vapour lamp, is actually beneficial.

There is another reason for utilising a source of energy which does not produce a large proportion of short irritating rays, and that is the risk of producing cancer of the skin. I am well aware that no case has been recorded at the Finsen Institute, nor did Sequeira at the London Hospital see one, but the carbon arc was the apparatus chiefly employed at these places. The mercury vapour lamp gives rise to rays to which the human body is not ordinarily subjected. It is well known that cancer of the skin can be produced

FIG. 8.—Spectra from Different Sources.

A. Siemens' White Flame Carbon.
B. Conradty's Noris Chromo Brilliant White Carbon.
C. Mercury Arc.

by X-rays and that it is the longer superficial rays which are responsible for its production rather than the shorter penetrating rays. The longer X-rays and the shorter ultra-violet rays are approximating to each other in wave-length and both are very superficial in their action. It is also known that X-ray cancer may appear many years after the cessation of all treatment. General ultra-violet radiation treatment is of comparatively recent origin, and it is yet too soon to say definitely that no risk is run by the administration of these short ultra-violet rays over a prolonged period such as is required for the treatment of tuberculous conditions. This warning has long been held out by Sir Norman Walker, and it has more recently been given by MacKee.[70]

Nor is this danger merely a fanciful one. There is some experimental evidence which suggests that the rays from the mercury vapour lamp are not so harmless in this respect as some observers would have us believe. Findlay[71] working at the Cancer Research Institute found that mice exposed to ultra-violet rays for not less than eight months may develop papillomata and epitheliomata of the skin. When the mice were tarred in addition, the cancer appeared more quickly. In his experiments Findlay used the mercury vapour lamp.

It may be objected that eight months is a much greater proportion of a mouse's life than would be the period during which a human being would be subjected to radiation. This objection carries no weight, as many tuberculous cases have to be radiated for years more or less continuously to get the condition cured, whether it be skin or joint or bone tuberculosis. The objection is also robbed of much of its force by the case, reported by Colquhoun,[72] of a man who had

radiations only twice a week for as short a period as eighteen months. These radiations were given by an unqualified person and the treatment was stopped only because the practitioner died. The patient was a man of 27, and he developed numerous keratoses on his back as the result of his treatment. Later the keratoses resolved spontaneously, but such resolution is rare, and it may be due, as Colquhoun suggests, to the age of the patient. Had the patient been older or had he had radiations for a longer period, it is more than likely that malignant changes would have supervened. In this case, also, it was the mercury vapour lamp which was employed.

Recently Savatard [73] showed a case where carcinoma supervened on a lupus scar, the patient having received ultra-violet radiations. He also mentions two others where malignant changes had arisen on the areas treated by ultra-violet rays. In each of these three cases the lamp employed was the mercury vapour lamp.

It is interesting to note, in connection with the type of lamp which is to be chosen, that Huldschinsky,[74] to whom we owe the discovery of the curative power of the mercury vapour lamp in rickets, has recently favoured a different type of lamp which produces radiations more approximating to sunlight.

The disadvantages of the carbon arc are said to be the length of time required for treatment, the susceptibility of the arc to draughts, the fumes from the carbons, and the cost of running the apparatus.

Against the first of these may be set the better results from this type of lamp and the ease with which a number of patients can be treated at one time. In private work two lamps should be installed and the patient seated between them. In this way the time

is cut down considerably. Such an arrangement of lamps is more economical in running as less current is wasted in the resistance.

If a screen is placed between the window and the lamps, they should burn steadily and the arc will not be blown out.

The fumes from the lamps are perhaps the most serious objection, but with care in the choice of carbon much can be done to mitigate this, and with efficient ventilation of the treatment room it should not arise at all. This subject will be more fully discussed in a subsequent paragraph.

The cost is certainly greater than with the mercury vapour lamp, as apart from the cost of the carbons, more current is consumed. Against this, however, is to be set the greater benefit derived by the patient, and also the fact that many more patients can be treated at one time with a carbon arc lamp than can be treated with a mercury vapour lamp. This reduces very materially the cost per patient, and the difference in the end is not so great as it would appear at first sight. In private, where patients are being treated singly, the cost is certainly greater, but as has been pointed out by Strandberg,[75] the course of treatment does not require to be so long with the carbon arc as with the mercury vapour lamp, and that is a very great consideration from the patient's point of view.

Apart from the distinct advantages which have been indicated incidentally in the preceding paragraphs, there is another, and that is that the lamps are interchangeable, and that the output is constant throughout the life of the lamps.

The mercury vapour lamp has definite disadvantages also. It is very fragile and easily broken. If the fingers are placed on the quartz tube, a mark is

permanently left there. The lamps are not interchangeable, and if a lamp is changed during the course of treatment, the scheme of dosage must be revised. There is no margin of safety with the mercury vapour lamp.

The output from the mercury vapour lamp diminishes with age, as has already been shown, and consequently the lamp must be tested periodically for its intensity of radiation. On account of the decrease of output, the time of exposure must be longer the older the lamp gets, and so the apparent saving in time by the use of this apparatus is not realised.

The heating of the treatment room is important, and ought not to be judged merely by the operator's sensations. A thermometer is essential to guide one as to the temperature of the room. The temperature must not be less than 60° F. and preferably about 65° F. Even that is too low for some elderly or debilitated patients, and in such a case it ought to be 70°.

Whatever type of apparatus is used, the room in which the treatment is given ought to be satisfactorily ventilated. After considerable experimenting in my own house, I have come to the conclusion that a gas fire is the best method of heating and ventilating the room. I have given an exhaustive trial to electric heating, in favour of which I was prejudiced, and also to central heating, but was forced to the conclusion that with a gas fire the odour from the products of combustion was much less noticeable and the atmosphere much purer than with the other methods of heating. As I have two 20-ampere lamps in my consulting-room, the test was rather a severe one. With a gas fire there is always a marked current of air up the flue, and this is lacking or at least much less definite with electric radiators or central heating, and consequently with the

latter two the fumes are not drawn out of the room in the same way. The ozone from a mercury vapour lamp is also much less noticeable with gas fire heating.

In hospitals, of course, the heating is central and consequently the question of ventilation is different. Whatever type of apparatus is employed there must be efficient ventilation. It is unfortunate that in most places the rooms set apart for light treatment have not been specially designed and built for that purpose. The ideal would be a room where an exhaust fan could be placed at the roof, sucking the air from the room into a shaft which leads outside. The arrangements which we have in the wards of the Royal Infirmary, Edinburgh, would be equally satisfactory. Here the air enters near the floor of the ward and is sucked out through shafts situated near the roof at each corner of the ward. In this way a perfect ventilation is produced. Whatever method of ventilation is employed, there must be a sufficient inflow of fresh air.

In some treatment centres, for the sake of purifying the air, apparatus for supplying ozone has been installed. When the treatment centre is situated in a congested district where there is normally a lack of fresh air, such apparatus may be necessary, but I have never found the need for it in our treatment rooms at the Royal Infirmary nor at Leith Hospital.

There is one point in connection with the treatment room which is of some importance. Many writers state that the walls should be white, so that the rays are reflected back to the patients, who thus get enhanced benefit. The extra benefit which they get in this way must be small and cannot be commensurate with the discomfort to which they are subjected. When patients sit with their backs to the lamps, they remove their goggles as a rule and read or knit. If the walls are

white, the patients have a glaring white area in front of their eyes and they have to sit and face this for an hour or more. The discomfort which they suffer from this glare is quite unnecessary, and can be avoided by having the walls of the treatment room of a dark colour and a dull surface. Those who have been subjected to the glare from the white walls can best appreciate the darker ones, and when patients have to sit for a few hours, as in group treatment they must do, everything ought to be done to enable them to sit in comfort.

From what has already been said, it will be clear that I am of the opinion that for serious, all-round work the carbon arc lamp is the apparatus of choice. This applies whether the installation is for hospital or private work. It is always desirable to instal arc lamps in pairs. They can be run in series and less current is consumed in the resistance and it is possible to treat more patients at the same time. In hospital work the patients can be arranged round each lamp, and so double the number can be treated, while in private work the patient can be seated between the lamps and so have the front and back of the trunk irradiated at the same time, thus shortening the duration of each treatment without lessening the dose of radiations. It is not advisable, however, to place three or four lamps in the series in the ordinary circuit. This cuts down the voltage across the arc to such an extent that there is a relatively small output of radiations with corresponding loss of benefit.

When the lamp has been chosen, the question of its suspension arises. If it is to be left in one position and merely raised and lowered when necessary, suspension from a pulley wheel with a similar wheel near the wall to carry the cable with the counterweight attached will be sufficient. If, however, it is desired to have it

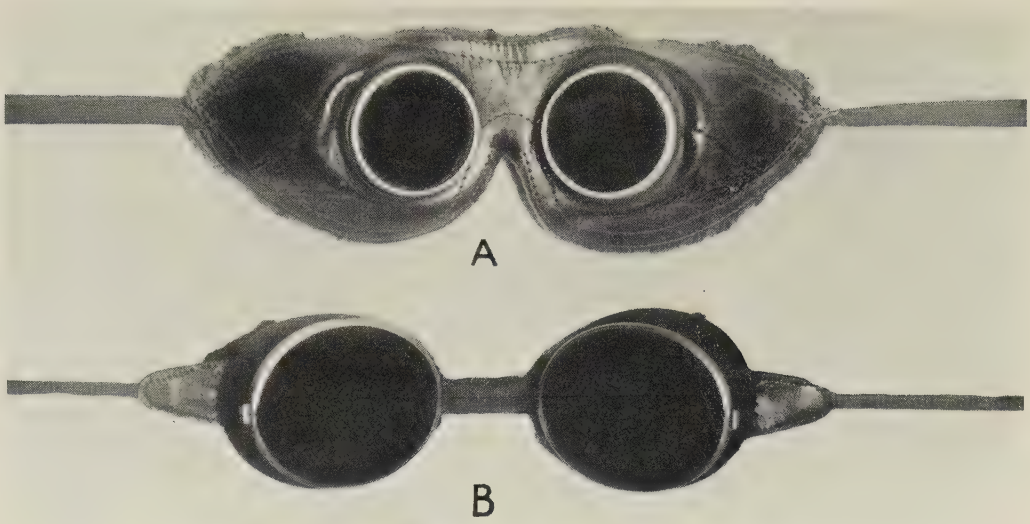

FIG. 9.—Protective Goggles.

A. Unsuitable. B. Suitable.

suspended so that it can be moved laterally, a different method of suspension must be adopted. A rail may be erected near the ceiling and on this runs a pulley carriage from which the lamp is suspended. The agents who sell the lamps have the many types of suspension illustrated, and these ought to be studied to get the best for the purchaser's special requirements. It is possible to have a frame with the lamps suspended from it, but this arrangement is cumbersome to move and the other method of suspension is preferable.

When the mercury vapour lamp is chosen, one must decide whether it is to be of the atmospheric or vacuum type. Again, the question of suspension will arise. It may either be suspended from the ceiling and so have a fixed position, or it may be fixed to a wall-bracket. It may also be placed on a stand which can be moved about the room as required, as illustrated in Fig. 5 (p. 60). The makers' catalogues give illustrations and details of these different forms and again the type which suits the purchaser's special requirements and conditions should be chosen.

Whether carbon arc or mercury vapour lamp be chosen, the patient and operator must wear goggles during the exposure. Many varieties are on the market. Some, it would seem, do not completely cut out the ultra-violet rays, and others pass so much light that the patient does not feel comfortable while wearing them. A dark glass is preferable, either green or brown. Some goggles, too, do not allow of any ventilation, but have the glasses set in leather or other impervious material. These are to be avoided, as perspiration condenses on the glasses and takes away from the comfort of the patient and renders it difficult for the operator to see properly what is going on in the treatment room. There is a type which has a

woven cloth fabric at the sides and these are, in my opinion, the best type. The mesh is close enough to prevent any ultra-violet rays penetrating, while it allows evaporation of the perspiration, an important item when the patient has to wear goggles for an hour or more. The accompanying illustration (Fig. 9) shows a type which is, in my opinion, not satisfactory and a type which is.

A difficulty with regard to goggles is the question of sterilisation. This can be got over by the use of a mask of gauze below the goggles, holes being cut out for the eyes if the patient so desires. Some patients prefer to place a small handkerchief below the goggles, not so much from the point of view of infection, but because they wish to prevent the face getting red or pigmented. This device, however, gets over the difficulty of disinfecting the goggles. Some varieties allow the glass to be taken out for sterilising, but it is not the glass which requires to be sterilised but the part which comes into contact with the patient's face and head.

Instead of goggles a shade of stiff brown paper may be worn. This is perhaps most useful in the case of young children who tend to become frightened when dark glasses are tied on. The shade allows them to see a certain amount and as long as they do not raise the shade or lift the head so as to look under the shade at the light, there is nothing against its use.

There is a type of protection which is useful for the nurse or operator in charge of the lamps and who is constantly in the treatment room. This is a mask which completely shields the face. It is attached to a leather-covered metal band which encircles the head. The points of attachment are at the sides and they act as pivots on which the mask moves so that it can be turned up from the face, though it is still kept on the

FIG. 10.—Protective Mask—Raised.

FIG. 11.—Protective Mask—Lowered.

head. The shield is of a non-inflammable material and is of a pleasant green colour which is very restful. The colour is sufficiently dark to prevent the light being unpleasant and yet sufficiently clear to allow the wearer to see distinctly what is going on in the treatment room. The accompanying illustrations (Figs. 10 and 11) show the mask in its two positions, raised and lowered. The only drawback is that if the radiation is intense, a pair of goggles has to be worn underneath as it is not sufficient protection of itself against the ultra-violet rays. It prevents the face becoming pigmented, however, with white marks under the goggles as happens when goggles alone are worn.

Other masks which fit more closely over the face may be obtained, but they tend to be rather stuffy and uncomfortable when they are worn for any time, and in my opinion they are not so satisfactory as the one indicated above.

A couch in the treatment room is very necessary. It may be used for elderly patients or for infants, or again for patients who are not able to sit up for the time required for the treatment. It ought to be light enough to be moved without difficulty, and yet substantial enough to prevent it being moved by a person accidentally coming in contact with it. For infants a couch in the form of a semicircle is helpful. When it is in this form, three infants can lie on it at the proper distance from the lamp and be in charge of one nurse. It is essential in a hospital or special clinic if many infants are being treated, to have them under the charge of someone other than the nurse in charge of the apparatus, and the type of couch just indicated allows one nurse to look after satisfactorily several children at one time.

CHAPTER VII

TECHNIQUE AND DOSAGE

Factors influencing Dosage. Value of Dosimeters. Influence of Temperature and Sweating on Dose. Area of Skin Exposed. Interval between Doses. Latent Period. Erythema. Pigmentation. Hypersensitiveness. Signs of Overdose. Permeability of Artificial Silk. Changing type of Lamp during Course of Treatment.

THE question of technique and dosage in the treatment is all-important in order to obtain satisfactory results. The amount of radiation which a patient receives depends on three main factors:

(1) The intensity of the source of radiation.
(2) The duration of exposure.
(3) The distance from the lamp.

The first two need no comment as they are obvious. The third factor, however, requires some explanation. Ultra-violet rays, in common with light and X-rays, follow what is known as the law of the inverse square, *i.e.*, the intensity of radiation is in inverse proportion to the square of the distance from the source of radiation. If a patient were being treated at two feet and then were placed at double the distance, four feet, the amount of radiation received would not be half but a quarter of what was received at the shorter distance. Similarly, by halving the distance, the dose is quadrupled. It will at once be understood how important it is to ensure that the patient is kept at the proper distance from the lamp, or somewhat unpleasant results might ensue.

Another factor which enters into the dosage is the angle at which the rays fall on the skin. The rays which fall perpendicularly on the skin, are more effective than those which fall on it at an angle, and the more they deviate from the perpendicular the less effective they become. The more acute the angle at which the light falls on the skin, the greater is the proportion reflected and the less absorbed. At the same time, in practice this is not a very important point, when working with the long flame arc at all events. With such an arc and the patient at a distance of three feet from the lamp, the angle of incidence of the rays is not very acute and consequently the greater proportion is absorbed. It is possible to cause redness extending from the shoulder to the lower part of the back under these conditions, and yet no difference in the intensity of the redness be apparent. The nearer the patient to the source of radiation, however, the more important does the angle of incidence become.

Many dosimeters have been placed on the market, and with them are given instructions for their use, but they are all worthless from the point of view of regulating the dose. They may tell the amount of ultra-violet rays present in the source of radiation, but they cannot tell how the patient will respond to the radiations—and this is the only thing that matters. To illustrate this point I may be permitted to quote the experience of two patients, a gentleman of 70 and a lady of about the same age, whom I treated a few years ago. The treatment was begun on the same day, the lady informing me at her first visit that she had a sensitive skin. Before they had had seven treatments the lady was receiving six times the dose the gentleman was able to stand. The dosimeter would have indicated

the same amount of radiations from the source in each case, but the patients responded to it in different ways. For all practical purposes such means of measuring the dose are valueless.

Some observers advise the use of a perforated armlet to test the sensitiveness of the patient's skin and so tell what dose should be given. This, in my opinion, is quite unnecessary and in many cases is entirely useless. In the cases quoted above, for example, the initial doses were the same, and it was not till after the third dose that their apparent response was different, due, to a certain extent, to the man's skin being moist as the result of his effort to avoid being late for his appointment. In children the skin reaction lags very considerably behind the general symptoms, and it is possible to overdose a child badly without any sign of redness appearing on the skin. Again, some adults are hypersensitive to radiations and may show marked general symptoms without any sign of redness. There is no settled or definite method of dosage. No two patients necessarily react in the same way, and each one must be dosed according to individual requirements and response. To attempt to work by rule-of-thumb is to court failure. The response of the patient is the indication for the next dose, and to judge what this must be can be acquired only by experience. So we see that experience is the only satisfactory guide to dosage. When the varying results in patients with similar lesions treated at the same lamps are contrasted, it would appear that there is something in radiation therapy that we do not yet fully understand.

In clinics where many patients are treated at one time, it is hardly possible to dose each patient individually, and one must then keep to the minimum

dose for all and so avoid reactions which give rise to discomfort. With the white flame carbons already mentioned, patients can ordinarily be given fifteen minutes at a distance of 3 feet as an initial dose, and the time increased two to three minutes each day till one hour to chest and back is given. I have never found it necessary in ordinary work to give a child a smaller initial dose than an adult, and I have not yet seen a child receive an overdose through this having been done. This is also the experience of Sequeira and O'Donovan at the London Hospital.

From the variation in intensity of the two types of mercury vapour lamp, it is obviously impossible to give any rule for an initial dose, and each lamp must be tested on the operator's own skin before attempting to use it on a patient. This gives an approximate idea of the time required to produce redness and the dose must be gauged accordingly. It is not usual to give an exposure longer than half an hour with a mercury vapour lamp, and this is reached only very gradually.

If the skin is warm and moist, the reaction will be greater than if the skin is cool and dry.

The mucous membranes are slightly more sensitive than the skin, and so require a rather less dose to have the same effect produced.

Some workers do not believe in exposing much of the patient's skin to begin with. Eidinow,[76] for example, states that only a sixth of the skin should be exposed at one time and then there should be an interval of ten to fourteen days before another dose is given to this area. In this way he claims that the greatest increase of the bactericidal power of the blood is obtained. In my opinion, too much stress is laid on the increased bactericidal power of the blood. It is only

one part of the picture and only one form of response on the part of the patient to the treatment; other factors coming into play may counterbalance, and more than counterbalance, any temporary decrease in the bactericidal power of the blood. I have not yet seen any ill effects from exposing as much as possible of the body surface daily. Sequeira[77] has tried the piecemeal exposure outlined by Eidinow and was compelled to give it up on account of the poor results he obtained and to return to the full exposure of the body surface.

The interval which elapses between doses depends to a large extent on the patient's response to the previous dose and the ability to attend for treatment. It also depends on the views which the worker holds with regard to the need for producing an erythema. Personally, I do not attempt to produce redness and I ask the patients to attend daily for five or six days a week. In hospital work they attend six days a week when they can do so. In some cases it is impossible to get patients to attend daily on account of business or domestic duties, and one has then to be content with an exposure every other day, but I do not think that the results are so satisfactory as when the patient can attend more frequently. If it is thought desirable to provoke an erythema, it is advisable to wait till all redness has passed off before giving the next dose. If a patient is away from treatment for five to seven days there is no need to reduce the dose on the resumption of treatment even though the full dose has not been reached, except perhaps if only three or four doses altogether had been given. If an interval of a fortnight elapses, the dose on resumption should be half that given at the last attendance. After a month's absence it is necessary to begin again.

When an exposure to ultra-violet rays is given, no visible changes occur at the time, but after an interval of from four to six hours redness of the skin will appear if the dose has been sufficiently large. Sometimes the erythema does not manifest itself until some twelve hours later, while in certain cases it appears as early as four hours after the irradiation. The redness may be general over the skin that has been exposed, it may take the form of aggregations of small itching papules, it may be scarlatiniform, or it may resemble measles. As a rule it is accompanied by a certain amount of irritation. The redness may be slight and pass off within twenty-four hours, it may be more intense and last forty-eight hours and be followed by slight or considerable desquamation. The desquamation may be branny in character or larger flakes of skin may peel off. The reaction may be so severe that blistering occurs and in this case it generally appears about four hours after the treatment has been given. If the dose has been grossly excessive there may be actual destruction of the superficial skin tissue resembling a burn and with toxic symptoms similar to those following a burn.

The irritation which accompanies the redness may be slight or severe and may even prevent the patient from sleeping. It is advisable to apply a lotion to soothe down the irritation if it is troublesome. Two formulæ which are useful are:—

℞

Sulphur. Precip.		℥iss.
Calaminæ Prepar.		℥iij
Pulv. Zinci Oxid.		℥iij
Glycerini		℥iss.
Aquam	ad	℥vj

Misce. Fiat lotio.

Sig. Shake and apply to the affected parts.

℞
Liq. Plumbi Subacet.
Liq. Carbonis Deterg. . . . . āā ℥ij
Pulv. Zinci Oxidi.
Glycerini . . . . . āā ℥iv
Aquam . . . . . ad ℥vj
Misce. Fiat lotio.
Sig. Shake and apply to the affected parts.

In no circumstances should grease be applied to an inflamed skin as it almost invariably increases the irritation. Ordinary dusting powders may be used instead of the lotions to soothe the irritation, but on the whole the latter are more satisfactory. As a rule the irritation passes off as the redness subsides.

It is frequently said that the skin which is ordinarily exposed to the sun and air is more resistant to radiations than that which is normally covered. This is certainly what might be expected, but it is not so in a large number of cases. There is usually a V-shaped area at the upper part of the sternum left exposed in women, and in nearly half the women I have treated, I have found that this area and the skin of the neck and face redden much more easily than the rest of the skin of the chest and back.

Another general statement frequently made is that fair people react more briskly than dark people. This statement also is too sweeping. I have frequently found that dark people have a much more vigorous reaction than fair people. Sequeira and O'Donovan[78] state that more severe reactions occur in brunettes. On one occasion I was treating two sisters-in-law together. One had black hair, the other light brown. The dark patient reddened easily and I had to give her a shorter exposure than the fair one who could stand as much as 50 per cent. more at each dose without developing any sign of redness.

Much discussion has been aroused by the question of whether or not an erythema should be produced. Some workers hold that no beneficial result can be obtained unless there is some skin redness. Those who make such a statement, can have little or no experience in the treatment of children, as these redden with difficulty, and indeed can be greatly overdosed without any sign of redness occurring. I have treated a child of six who had acidosis and who received 15 doses in two weeks and two days without any redness being produced, and who put on 4½ lb. in weight in that short time. Her father—a doctor—informed me at the end of her treatment that she had become the life of the nursery, instead of being limp and listless as she had been before treatment began. Similarly in adults there is no need for redness. A lady whom I treated for debility following a gynæcological operation, put on more than 4 lb. in one week without showing any redness. Under these circumstances I can hardly accept the statement that without redness there can be no benefit.

Rothman[79] states that in Jesionek's clinic they are careful to avoid the slightest trace of dermatitis in general radiation treatment. He holds that it is never an advantage, and may in certain circumstances be a disadvantage.

In addition to the effect which occurs after a latent period of about six hours, there is another effect which I am sure must have been observed by other workers, though I have not so far seen it described. This is an immediate or practically immediate effect. Perhaps I may make my meaning clearer if I describe two of the cases in which I have seen it occur. On one occasion I was asked to radiate a patient who was acutely ill. She had a septicæmia due to a hæmolytic

streptococcus, and she had two septic thrombi in her right thigh. She had a temperature of 102-103° F., and I declined to undertake the task of treating her as I considered that her condition was so hopeless that no benefit could be expected from radiations. Her doctor begged me to treat her as it seemed to be her only chance and I rather reluctantly consented. When I saw the patient, all my hesitation returned. She was delirious and was not aware of my presence. I gave her a short exposure and informed the matron of the nursing home that the patient might be expected to sleep in about four hours after the treatment. She was sleeping peacefully in less than half an hour. The following morning she had a better colour, this opinion being given independently by her doctor and the matron. That evening she had a second dose and sleep again followed quickly. Though her condition seemed better next morning, the task had been too much; the toxæmia had been too profound and she succumbed that evening. The other patient was an old lady of 79, whom I was asked to radiate for bronchitis and pulmonary congestion following influenza. The doctor had given a rather gloomy prognosis, and when I saw the patient's laboured breathing I agreed with him as to the outlook and was rather unwilling to begin treatment. I gave her a short exposure, however, and the next day I was informed that within an hour of her treatment she was sleeping "as quietly and as peacefully as a babe," to use her sister's words. As the patient was rather deaf and had not heard my remark to her sister and the nurse about the probability of her soon sleeping, there could not be any possibility of a psychic effect. The patient's sister and the nurse were amazed at the difference between the noisy laboured breathing before

radiation and the quiet peaceful respiration so soon after it. After the second dose sleep again came quickly and with subsequent exposures an improvement in her condition so that after the sixth dose the doctor in charge was able to say that the bronchitis had completely gone and to revise his gloomy prognosis. In spite of her age and a damaged heart this patient steadily improved.

In a private communication, a doctor who had worked in a maternity hospital informed me that he had found an immediate fall in the blood-pressure of pre-eclamptic patients who were submitted to radiations. This apparently is the same effect as I have indicated.

Not infrequently when radiating children, I have been informed by the mother that the child has been very hungry and has demanded something to eat on the way home after having treatment. As the child was not in the habit of getting anything to eat between meals, this unusual demand could only have been the effect of the radiations, as it has occurred in children coming for what one might term prophylactic treatment as well as in children convalescing from acute illnesses.

Time and again I have been informed by patients that even after their first exposure they were able to walk more vigorously and hold themselves more erect than was the case while coming to my house for treatment. I am aware that some sceptics will say that this is a purely psychic effect, but in the cases I have quoted above this cannot be the explanation. In the septicæmia and pre-eclamptic cases it may be the oxidation of toxins which was responsible for the immediate effect, but whatever the explanation, the reaction is one which appears to be quite definite.

After a dose of radiations which gives rise to a brisk erythema, or after several small doses without redness

a certain amount of pigmentation begins to appear. This deepens with subsequent treatment until in some cases the chest and back are a rather dark brown. The amount of pigmentation which occurs depends to a large extent on the colouring of the patient. Dark people pigment as a rule more than do fair people, and the carbon arc lamp gives rise to a darker pigmentation than does the mercury vapour lamp. Some aspects of pigmentation have already been discussed in the chapter on the biological effects of light, and need not be dealt with again here.

Much discussion has taken place with regard to the need for pigmentation. Some observers state that no improvement takes place in the absence of pigmentation, and indeed it has been said that the amount of pigmentation can be used to forecast the course of the disease. I do not think that such a sweeping statement is justified. Not infrequently patients are seen who progress in a perfectly satisfactory manner without showing any sign of pigmentation. Freiberg [80] states that he has seen many very blond patients who made relatively rapid recoveries without having attained degrees of pigmentation comparable to those of other patients who have been less fortunate in the amount of their improvement. He also can cite cases in which the pigmentation became of the deepest and in which it was necessary to record a standstill at this very period. It is possible to point to patients in whom pigmentation was deep and whose original disease was well advanced in healing in whom other foci of tuberculous character with definite destructive nature developed. He concludes that it is impossible to rely on pigmentation as an accurate gauge of the patient's progress.

Opinion now seems to be tending definitely to the view that there is probably no relationship between

pigmentation and progress. It may be that a dark person who ought normally to pigment and who does not, will not benefit to the same extent from radiations as one who does, but the statement that pigmentation is necessary is too sweeping and is contrary to fact. The following illustration, for which I am indebted to Dr O'Donovan of the London Hospital, is interesting in this respect. Twins, brother and sister, were being treated at the London Hospital for tuberculosis of the skin. The boy was dark, the girl almost an albino. The boy was used to regulate the dose for both. Both children improved equally rapidly. The dark boy pigmented, but of course the albino girl did not. With such an example it is hardly possible to maintain that pigmentation is necessary.

It is sometimes stated that longer doses are necessary to produce benefit when pigmentation has occurred, but this is not my experience. Cases of lupus have frequently been observed to improve steadily under the same dose of radiations even though the skin was almost the colour of mahogany.

Occasionally patients are met with who are hypersensitive to radiations. Two of the cases which I have observed and which show some points in common and some very dissimilar, are interesting in this respect. The first is that of a lady who came to me for treatment for debility following influenza and bronchitis. Within an hour of her first exposure she suffered from a feeling of tightness and oppression in her chest and large urticarial wheals appeared on her trunk and limbs. She was so anxious to continue the treatment, and so certain that these symptoms would disappear as the treatment progressed, that she did not inform me of them until some weeks afterwards, even though I asked her about her general condition at each of the first few

visits. Fortunately her skin proved somewhat intolerant and the exposures were kept short on that account, and tolerance both as regards skin and general condition was gradually established. An interesting feature of this case is the fact that the tolerance has lasted. The lady has had short courses of treatment every winter since then and has shown no signs either of skin or general intolerance.

The other patient was also a lady and she had the same symptoms, but no skin intolerance. In fact there was no redness at all. She had a second dose with similar chest symptoms, but they were less marked, and I have no doubt that after a third dose they would not have troubled her at all. She was a little alarmed, however, even though I had warned her that they might occur after the second dose, and she discontinued the treatment. This case shows the uselessness of the perforated armlet as a means of estimating the dose which the patient should be given. Had I given her a dose which would produce an erythema, her chest symptoms would have been much more severe and alarming. These cases are fortunately not common, but when they do occur they are most disconcerting to the operator as well as distressing to the patient.

It is sometimes said that patients should not receive radiations while they are menstruating. Some women do not care to come at these periods, but others do not wish to interrupt the treatment. I have not seen any ill effect from a patient continuing the treatment during the menstrual period, and unless patients express the wish to discontinue at that time, I do not suggest that they should do so.

Ordinarily a dose of ultra-violet rays gives rise to a feeling of exhilaration. If a dose has been too great, instead of this exhilaration there is a feeling of depression

and limpness. After a latent period of from two to four hours there may be some headache and feeling of chilliness. In children there is loss of appetite, restlessness and sleeplessness, diarrhœa may occur, and the child is apt to be fretty and irritable. It is important to ask at each visit for the first few exposures about these symptoms. It is especially important in children, as in them there is not any skin redness to guide one as to the effect of the previous dose, and a considerable overdose may be given without any erythema appearing. If any of these symptoms have occurred there should be an interval of a few days before the next dose is given.

One is sometimes asked by female patients if it is possible to wear a complete garment of artificial silk or other material during the exposure to radiations. There is no doubt that artificial silk is more pervious to the rays than natural silk is, but this does not mean that any considerable quantity of beneficial rays gets through a garment of this material. I have tested three pieces of artificial silk with regard to their permeability. These were ordinary commercial pieces, one was white, one red and one blue. They were fastened on the arm so that an area of bare skin was left between them. The arm was then given a dose of rays sufficient to produce a brisk erythema. The skin which was left bare reddened, but there was no sign of erythema under any of the pieces of artificial silk. It may be that there are some varieties of artificial silk which will let a fair proportion of beneficial rays through, but the above test shows clearly that all artificial silk does not do so. If a garment is worn which is not pervious to the rays, the patient will obviously not receive any benefit from the treatment, and the rays, not the garment, will be blamed. In this

way the treatment will fall into discredit. Leonard Hill [81] states that a zephyr garment of artificial silk is the least obstructive, if a garment must be worn, but that even a zephyr screens off more than 50 per cent. of the rays. I advise women to sit in ordinary knickers with elastic knee-bands and an elastic waist-band. The garment can be pulled up the thighs as far as possible, and in this way as much as possible of the body surface is brought under the influence of the rays. I have not had any trouble in getting patients to have their treatment in such a garment. If they hesitate, the explanation of the screening effect of a more complete garment convinces them.

Some workers seem to use the carbon arc, the tungsten arc and the mercury vapour lamp indiscriminately, giving some doses with one, and then some with another. They do not indicate what are the reasons which cause them to change the lamp or go back to the original lamp later, as some do. Such technique is bad, and indifferent results are all that can be expected. Other workers begin with the carbon arc and then finish off the course of treatment with the tungsten arc or mercury vapour lamp, thus giving, as they say, a more intensive radiation. It is difficult to see the reason for this procedure. It is admittedly the case that these lamps give off a greater proportion of ultra-violet rays than does the carbon arc, but it is the shorter rays in which they excel, and these do not penetrate the outer layers of the skin and so are worthless from the point of view of treatment. In addition to this a screen of pigment is usually formed towards the end of the course of treatment, and if, as some hold, this pigment is a protection against the ultra-violet rays, it is obviously bad workmanship to give a larger proportion of the rays which this screen is

destined to keep out. It would be more logical to give the follow-up course with the carbon arc, as it has a greater proportion of the long penetrating rays, and these are more likely to get through the less dense pigmentation which the mercury vapour lamp produces. I am, however, of the opinion that it is entirely unnecessary to change the type of lamp during the course of treatment. In many cases of tuberculosis of skin, bone, and gland, both in hospital and private work, I have seen steady improvement continue under carbon arc radiations even though the patient is deeply pigmented as the result of several months' treatment. Again, Rollier and other workers do not seem to find it necessary to add short rays to the treatment after the patient has progressed to a certain extent, and it must be remembered that the solar radiation does not contain any rays of a wave-length less than 2900 Å.U. Satisfactory results cannot be expected in the absence of satisfactory technique.

CHAPTER VIII

CONTRA-INDICATIONS AND RISKS. INDICATIONS FOR TREATMENT

Lessening number of Contra-Indications. Radiations in Acute Illnesses. Nephritis. Circulatory Diseases. Old Age. Infancy. Diabetes. Radiations and Injections of Gold Preparations. Indications for Treatment. Debility. Tiredness due to Overwork. Persistent Cough. Length of Tonic Course. Prevention of Respiratory Troubles. Medical Research Council Report. Contrary Opinions.

FORMERLY there were many conditions which were supposed to contra-indicate the use of ultra-violet rays, but many conditions formerly looked on in this way are now no longer so regarded. A notable instance of this is pulmonary tuberculosis. It is not so very long since this condition was regarded as a definite contra-indication, but many observers have shown clearly that in a subacute or quiescent stage phthisis may indeed be benefited. In the same way it was long held that acute conditions should not be treated with radiations. The reason for this opinion was probably the fact that it has been shown that the bactericidal power of the blood is diminished if radiations are given in acute illnesses. It has now been definitely proved that acute illness is not a bar to radiation treatment. The following example illustrates this. I had recently to radiate a lady who was acutely ill with broncho-pneumonia. She had a temperature of 101° F. and was sleeping badly. After the first

dose she slept better, and the following day had a much better appetite. She had daily doses and there was a steady fall of temperature with a steady improvement in her appetite and general condition. It may be that the radiations destroy the toxins, but whatever the explanation is, I am convinced that the bactericidal power of the blood is only one factor in the patient's condition and other reactions to the treatment must be taken into consideration. Even if the improved sleep were the only result of the radiations, it means a great deal and must have a beneficial effect on the condition of the patient. In acute illnesses, however, the dose must be a good deal smaller than that which would be given to a non-febrile case. It may be that, as experience is acquired, the other conditions in which radiations are said to be contra-indicated, will be removed from this category, and will be found to be quite suitable for that treatment.

It has been said that nephritis is a disease in which radiations ought not to be given. I am doubtful if this is correct. Recently I was asked by one of my colleagues at Leith Hospital to undertake the treatment of two children who had been in the ward under his care. I hesitated to do so when I was informed that they had had nephritis. I explained my hesitation, but agreed to give the treatment, especially as one of the children had had severe bronchitis and was still coughing badly; but I stated that the urine would have to be examined carefully each day, and the treatment stopped at the first sign of deterioration of the kidney condition. My colleague undertook to have this examination carried out and a report sent to me if necessary. I began cautiously to treat the children, but there did not seem to be any ill effect on the kidney condition. As radiations prove beneficial

in the pre-eclamptic state, it is a little difficult to see that they should be harmful in ordinary nephritis, and the two cases I have indicated tend to show that the danger of radiating in kidney disease has been somewhat exaggerated.

Marked amyloid disease is said to be a contra-indication, but it is doubtful if such a condition is often diagnosed in life. Advanced circulatory disease such as myocarditis, arterio-sclerosis, and uncompensated heart disease, are said to be unsuitable for treatment. In mental disease it is stated to be harmful in agitated melancholics, acute maniacs and epileptics, but the former two will hardly come within the province of the ordinary actinotherapist.

It has been said that old age is a bar to radiation treatment, but the case quoted on page 82 of the lady of 79 is, I think, sufficient to show that age is not a contra-indication. As she also suffered from arterio-sclerosis, the result obtained in her case is sufficient to show that that condition is not necessarily a contra-indication to radiation treatment. In fact the result was so successful, that the lady's doctor asked me to take apparatus to treat another patient of his, a lady of 82. She did well also, though the result was not so dramatic as in the former patient.

Sometimes one sees it stated that infants under three months are not suitable cases for radiations. This has not been my experience. I have treated several under that age, and have not found any ill effects resulting from the treatment. My youngest patient has been a child of 4½ weeks.

Diabetes, while not a contra-indication, is a condition which requires great care in radiating, especially if the patient is getting insulin at the same time. Indeed it has been said that radiations and insulin

should not be given together. I do not think, however, that the administration of insulin is a contra-indication to radiations provided one knows the risks concerned. Bloch and Faber[82] found that there is a fall of blood sugar after radiation equal to that following the injection of 3 to 4 insulin units. It is possible that those who state that radiations should not be given with insulin treatment, are not aware of this, and in that case it is certainly dangerous to give radiations. This is confirmed by a private communication I had from a young doctor in England, in which he informed me that while having insulin injections, he was advised by someone to have radiations. The result was that he nearly died of insulin poisoning. In his case the radiations had stimulated the pancreas to secrete more insulin. He had not known of this effect, nor had the doctor giving him the insulin, nor had the actinotherapist. The extra insulin secreted by the pancreas had lessened the amount he required to inject, and as he had been working on a practically steady dose of insulin, the requirements of the body were suddenly altered, and he had had too much injected with dangerous results. If, however, one knows the result of radiations on the pancreatic secretion and warns the patient accordingly, there is no reason to withhold radiations.

The risks in ultra-violet therapy are chiefly those of overdosage, the symptoms of which have been described in the preceding chapter. One risk which the patient ought never to be allowed to run is that of a burn due to the breaking of the quartz tube of a mercury vapour lamp during treatment and the mercury falling on him. The lamp should never be suspended over a patient. While such an accident may be rare, it is no consolation to the unfortunate

patient to be told so. The only way to obviate such a risk is to have the lamp suspended at the side of the patient and never above him.

The publicity which this form of treatment has received has not been without its drawbacks. Many people have installed the apparatus in their homes without having any knowledge not only of ultra-violet therapy, but also of electrical apparatus. Recently a death was reported as due to a shock from an ultra-violet apparatus, and an electrical expert who examined the apparatus, stated that a shock could have been got from it in five different ways owing to faulty insulation.

MacCormac and McCrea [83] record the case of a man who had a mercury vapour lamp suspended above his bed, and who fell asleep while having his treatment. He had an exposure of one hour and ten minutes instead of ten minutes. Needless to say he became gravely ill and was in a very serious condition for weeks before he began to improve. An interesting feature of this case is the fact that the back became red and swollen and later desquamated, though, as far as could be ascertained, it had not been directly exposed to the light.

The risks of conjunctivitis occurring as the result of inadequate protection of the eyes are so well known that one should never see such a complication, but it is extraordinary how frequently one has seen such cases where the person was allowed to gaze at the arc without goggles on. It is a somewhat humiliating fact that many doctors do not yet seem to realise that ultra-violet rays can be harmful to the eyes, and that they ought to be protected by the wearing of suitable goggles. Not infrequently I have had doctors enter my departments and make no attempt to protect their eyes, even though goggles were handed to them and they were asked to use them. In some cases I have

even had to have the lamps switched off to protect the doctor from the effects of his own lack of care.

Conjunctivitis due to ultra-violet light gives rise to considerable pain, photophobia and lachrymation. The symptoms come on about six hours afterwards, just as the skin reaction does. If the exposure has taken place in the evening, the patient is wakened from sleep by the intense pain in the eyes. Cold compresses should be applied and liquid paraffin instilled into the conjunctival sac. If liquid paraffin is not available, castor oil will suffice. If the condition is severe, morphine may have to be administered to relieve the intense pain.

While the risk of conjunctivitis is an immediate one, there is another risk which is more remote. This is the risk of cataract being produced. In this case it is the light rays rather than the ultra-violet rays which seem to be at fault. Many operators do not seem to realise that even momentary glances at the lamp, though not sufficiently prolonged to set up conjunctivitis, may result in changes in the lens if the practice is persisted in over a long period. Goggles should always be worn, therefore, no matter how short a time the operator may look at the lamp.

Injections of gold preparations are now frequently given in tuberculous conditions and also in lupus erythematosus. This seems to carry a risk with it if the patient is given radiations subsequently. Beaumont[84] describes a case of a patient who had received injections of sanocrysin and who had developed a lilac-coloured pigmentation of the parts exposed to the sun. Savy[85] mentions a similar case which was successfully treated with sodium sulphate. These cases were due to ordinary sunlight, but the same unfortunate results may occur after exposure to ultra-violet radiations.

It is too early yet to say what are the limitations of the remedy and it must be understood that it is not a cure for everything, as some enthusiasts would have us believe. At the same time, it is of great value and many conditions may be benefited by a course of radiation. In treating many diseases, ordinary investigations must be carried out and any faulty mode of living corrected. It is hardly possible that radiations can overcome bad habits and carelessness in looking after one's body, and ordinary remedies directed to these conditions must not be neglected. These investigations will be the ordinary ones which ought to be carried out whatever the treatment, and it is not necessary to specify them in dealing with the different diseases which will come to be mentioned later.

I am convinced that in ultra-violet radiations we have the finest possible tonic. In general, it may be said that any debilitated condition responds readily to radiations. **Debility** following pneumonia, influenza, operation, or even a bad cold, will vanish in a remarkable way and the return to health and strength again be greatly accelerated. Weight and appetite increase, convalescence is hastened, and the patient regains full vigour much more quickly than would otherwise be the case.

In this country, during the winter months the amount of ultra-violet rays from the sun is practically negligible, and therefore invalids do not benefit by convalescing in the country. Unless they are able to go abroad for sunshine, the benefit derived from a short stay in the country is not commensurate with the disadvantages. In these circumstances a course of ultra-violet radiations would be most beneficial.

In hospital work more use could be made of radiation therapy. There are few cases of acute illness which

would not be benefited by a course of radiations when the acute stage is past. Similarly, a course of treatment for a surgical case as soon after the operation as the patient can be moved with safety to the light treatment room, would help to make him fit to leave the hospital at an earlier date than would otherwise be possible, and in this way would help to solve the problem of extensive waiting lists.

There is a type of case which one does not see in hospital work, but which benefits in a marked way from a course of radiations. I refer to the person who is not suffering from any particular disease, but who is simply overworked and thoroughly tired. The business or professional man who has had a very strenuous time and who is not able to get away for a short holiday, the lady who has many social engagements which tire her out and which she is either unable or unwilling to relinquish—these benefit greatly from radiations. After even a few exposures there is a feeling that the day's work can be done with less fatigue, and by the time the course is finished there is a feeling of briskness and vigour and a sense of well-being which are in marked contrast to the limpness and listlessness which preceded the course. Even after two doses it is not uncommon to hear such a patient remark that he can walk more erect and stride out more vigorously than he could do before commencing treatment.

Another type of case where there is no real disease is the person who has a **persistent cough** without any signs in the chest, the type of cough which is so prevalent in winter and which would clear up if there were a short spell of mild weather. Ordinarily such a cough yields readily to radiations. In fact, I have known it cease after only three exposures, though it

had persisted for weeks before that. On one occasion a doctor who had heard me make this statement, and who was distinctly sceptical, asked me to prove it to him, as he had had a cough for six weeks which he could not get rid of by ordinary means. I pointed out to him that I had not guaranteed to clear up every cough in three exposures, but that I was willing to try to help him. His cough had gone completely after four exposures and he was convinced.

For a tonic course, I do not think it worth while giving less than twelve to fifteen doses. I prefer three weeks' treatment, five doses per week. It generally takes ten or twelve doses to work up to the full dose and I think it advisable to give several full doses as these, in my opinion, often do more good than double the number of small doses. If patients are not willing to take the number of doses I advise, I decline to treat them. If they have only three or four doses they do not get much benefit, and as the results have not come up to their expectations, they blame the remedy, saying that it is valueless, instead of blaming themselves. In this way the remedy tends to become discredited.

I am satisfied that ultra-violet radiations can raise the resistance to colds and respiratory troubles and ought to be given for that purpose to susceptible people. I know that I am treading here on debatable ground and that doubt may exist on this point in view of the Report[86] published by the Medical Research Council. The Report summarises the results of an experiment carried out among school children by Dr Colebrook, who found that there was a greater incidence of colds among the radiated children than in the children of the control groups. The Report seeks to disarm criticism of the results by stating that it is easy to criticise them and say that the dosage was too big or

too small, but that the results of the experiment must stand till some other similarly controlled experiment with different dosage takes its place. In spite of the Council's statement, I do venture to criticise the dosage employed in the tests and suggest that it was much too great. It is my personal experience that a child can be badly overdosed by an exposure much short of that required to produce an erythema. Other observers have had the same experience. In the Report of the Scottish Board of Health [87] we find it stated that: "The Glasgow experience thus agrees with the view already expressed that the erythema test cannot be taken as an index of the dose in the case of children. Very definite clinical response followed exposures that fell far short of what was necessary to produce any visible erythema. This observation led to a considerable reduction in the initial exposure times and to careful clinical observations of the response of each individual after a very short initial exposure." Dr Colebrook's dosage was just short of what was required to produce an erythema and was consequently much greater than that required to obtain a clinical response as indicated in the Scottish Report.

Other items in the Report of the experiment suggest that the dose was excessive. One child in each group was said [88] to be tired in the evening after the treatment and that this lassitude disappeared after the dose was reduced. Tiredness or lassitude after treatment is always a sign of overdose. The parents of two children in each group stated [89] that their children had been unusually tired and irritable during the time. Again these are signs of overdosage. As the children were drawn from a class where attention to body cleanliness was apparently not too strictly attended to in the ordinary circumstances, it is possible that minor degrees

of lassitude and irritability were not observed by the parents. But the facts stated in the Report itself are evidence enough that the dose was excessive. As Leonard Colebrook[90] has pointed out that overdosage reduces the bactericidal power of the blood, it is not to be wondered at if the incidence of colds was greater among the radiated children than among the other groups.

Too many contrary opinions have been expressed by competent observers to justify the statement in the Medical Research Council Report being taken too seriously. Evidence has accumulated from many quarters to prove that radiations can lessen the incidence of colds and respiratory troubles during the winter months.

Eidinow[91] has recently shown that the radiation of rabbits previous to giving them an injection of virulent staphylococci, results in the raising of their resistance to that organism, and it does not seem unreasonable to conclude that resistance may be raised to other organisms also.

There is a considerable volume of clinical evidence to support this view. Smiley and Maughan[92] found that there was a definite relationship between the incidence of acute respiratory infections and the average daily hours of sunshine. These observers state that there seems to be a group of people, rather more than 20 per cent., who are seriously susceptible to colds and that it is this group who are responsible for the winter epidemics. Any measure which would control the colds of the few, might well eradicate the big epidemics which cause so much loss of time and endanger so many lives. These observers irradiated once a week a small group of the susceptible persons, a control group receiving no treatment. The average number of colds for the

autumn term was 1·56 for the radiated students and 2·80 for the untreated. The figures for the next term were respectively 1·24 and 2·79. The authors suggest that the results justify the use of short weekly doses of ultra-violet rays in cases of marked susceptibility to colds where even a 40 per cent. decrease in incidence would be welcome.

The Report of the Scottish Board of Health[93] states that "it was noticed that the weight increased, there was an improvement in muscular tone and in the condition of the skin and *lessened tendency to catarrhal affections.*"

Eidinow[94] states that the treatment proved beneficial in lessening the susceptibility to colds and acute bronchitis; while Strandberg,[95] speaking of cases of laryngeal tuberculosis at the Finsen Institute, stated that it was observed that during the treatment the patients were extraordinarily immune to winter colds.

These observers may not all have had experiments controlled in the sense of the Medical Research Council requirements, but their observations are worthy of consideration, perhaps the more so as they were recorded incidentally to other observations and not with the specific object of testing the immunity to colds.

It may not be without interest if I quote two of the instances which have come under my own observation.

A patient who has been coming during the last two winters for treatment for extensive lupus vulgaris, works in a shop where she is exposed to draughts coming through the open door and also to the risk of infection from customers. Her mother and sister are both rather susceptible to colds, and when one or the other contracted a cold the infection went round the household, my patient being invariably infected. During the time she has been coming for treatment she has not suffered

from a single cold, though her mother and sister have been frequently affected throughout each winter. Even more striking is the case of a schoolboy. For the first four years after he began school he was off for one or two days each session with a cold. Some years ago I began to radiate him one week each month from November to March and he has not been off school with a cold since.

These again may not be controlled experiments, but it is difficult to avoid the conclusion that the radiations were responsible for the resistance to colds in both cases, and in the case of the boy there can be no question of impressions only, but of facts—colds sufficiently bad to keep him off school before radiations, after radiations no such absence.

With such evidence before me, it is hardly to be wondered if I do not accept the Medical Research Council statement, and if I continue to radiate patients who desire to obtain the benefit which, I am convinced, such treatment confers.

CHAPTER IX

DISEASES OF THE SKIN. VENEREAL DISEASES. INFECTIOUS DISEASES

Extravagant Claims. Tuberculosis of the Skin. Alopecia Areata. Furunculosis. Sycosis. Psoriasis. Herpes Zoster. Lupus Erythematosus. Burns. Pruriginous Dermatoses. Pruritus Vulvæ and Ani. Dermatitis. Pityriasis Rosea. Erythema Pernio. Erythrocyanosis Crurum Feminarum. Varicose and other Ulcers. Erythema Induratum. Dermatitis Herpetiformis. X-ray Telangiectasis. Leucoderma. Acne Vulgaris. Ringworm of the Scalp and Body. Impetigo Contagiosa. Diagnosis of Ringworm of the Scalp. Skin Conditions under Wood's Light. Soft Chancre. Sunlight and Syphilitic Rashes. Erysipelas. Diphtheria Carriers. Detection of Exanthemata by Ultra-Violet Rays.

It has been claimed by many writers that ultra-violet radiations are beneficial in most skin diseases, some go so far as to say that radiations are useful in the treatment of skin diseases from A to Z—Acne to Zoster. It is interesting—and significant—that dermatologists do not make such claims. They are in the habit of treating the various diseases with different remedies, and they are better able to appraise the value of a remedy such as ultra-violet radiations than are others not so well acquainted with the diagnosis and treatment of skin diseases. It is essential to be sure of the diagnosis before saying that the remedy benefits such and such a condition. One only requires to be attached to the Skin Department of a large hospital to realise how frequently even such simple conditions as psoriasis,

impetigo contagiosa and scabies are wrongly diagnosed. Under such circumstances a dermatologist may be pardoned if he does not accept the extravagant claims which are made for ultra-violet radiations in the treatment of certain skin conditions. There are, however, certain skin diseases which can be benefited by radiations.

It is often claimed that the bactericidal rays have a great influence in the treatment of skin diseases. They are, in my opinion, practically useless. If the organisms are on the surface, as in impetigo contagiosa, they can be readily killed with ordinary treatment. If they are deep, the bactericidal rays cannot reach them, as they are the more superficial rays, and it is putting the patient to quite unnecessary trouble—and expense—to attempt to treat the condition by radiations. The long ultra-violet rays and the light rays are the important ones in dermatology as they are in other work.

Tuberculosis of the skin, both in its manifestation as *lupus vulgaris* and as *scrofuloderma*, stands foremost as amenable to treatment by radiations. It is now more than thirty years since Finsen demonstrated to the world the change which could be brought about in lupus vulgaris by concentrated arc light. The treatment by general radiations marks as great an advance on Finsen's original method as that did on the remedies previously employed. The disadvantage of the Finsen method was the length of time required to treat an extensive case of lupus. General radiations do just as well in extensive cases as in localised ones.

It is sometimes alleged that general radiations alone will not cure lupus, but this is entirely erroneous. We have, unfortunately, a large number of cases of lupus in Edinburgh and the neighbourhood, and after an

FIG. 12.—Lupus Vulgaris before treatment with Tuberculin combined with local Ultra-Violet Radiations.

FIG. 13.—Lupus Vulgaris after five months' treatment with Tuberculin combined with local Ultra-Violet Radiations.

extensive experience with the radiation treatment of this disease, I have no hesitation in stating definitely that general radiations alone do cure some cases of lupus. At the same time, however, it may not be desirable to rely on this treatment alone, and I regularly employ other methods of treatment such as the application of trichloracetic acid or similar caustic to the edges of the lupus patch. In this way the cure of the disease is hastened. Local radiations by concentrated arc light may be employed instead of the caustics.

The action of local applications of light in this or any other skin disease is different from that of general light treatment. The local application aims at the deliberate production of a brisk reaction with hyperæmia of the diseased part and its neighbourhood. In this way the action is similar to that of the caustics mentioned above, and the latter are more readily available.

It has been said that injections of tuberculin ought not to be given to patients who are getting ultra-violet radiations. There is no reason why these injections should not be given. The accompanying photographs (Figs. 12 and 13) show a patient who had such combined treatment. She was treated at the Skin Department of the Royal Infirmary for extensive lupus on both sides of the face and neck, following tuberculosis of the cervical glands. She received tuberculin injections twice a week, and in addition the left side of the face had local applications of the Kromayer lamp. The right side improved greatly, but the left did even better, and the girl's parents were anxious that the lamp be applied to the right side also. During the War her condition deteriorated, as little treatment could be carried out, and when our Light Department was opened she was given general radiations and she is now completely cured and has been so for several years.

The type of lupus in which most dramatic results are obtained is the catarrhal. Even within a fortnight it is frequently found that the part is drier and looking healthier, but the clearing up of the catarrh ought not to be mistaken for the cure of the lupus, as is not infrequently done. Another type which does well, is that in which the patches are rather turgid and swollen. After a few weeks the lesions become much flatter and soon are level with the skin. The dry flat type takes much longer, but with perseverance cure can be brought about. Where there is much fibrous tissue, usually the result of previous X-ray treatment, the progress is much slower and the local treatment by spiking out the nodules of the disease with a pointed glass rod dipped in caustic is very necessary. More stubborn still is the thick warty type of lupus.

Scrofuloderma does well as a rule. The discharge may become more profuse to begin with, when there is a sinus, but as the treatment progresses, the discharge steadily diminishes and eventually ceases. The glands decrease in size and eventually disappear, while the infection of the skin steadily diminishes till cure results. It is unfortunate that there is so much delay in sending these cases for radiation treatment, as the greater the duration of the disease the longer is the course of treatment required to bring about a cure.

The type of tuberculous lesion which is the most resistant to light treatment is the pseudo-elephantiasis type, and I have rarely seen much improvement brought about by radiations in these cases.

It ought never to be forgotten in treating lupus by light or any other remedy that, while dramatic improvement may occasionally take place, patient and persevering effort over many months is necessary in the vast majority of cases. If Finsen had taught nothing else,

his name ought to be remembered because he taught the value of patience and perseverance in the treatment of lupus. Only by steady co-operation and effort on the part of both patient and physician can the desired end be achieved. There is no doubt, however, that the radiation treatment of lupus has opened out a new vision of life to sufferers from this disease behind many of whose lives lies a story of tragedy and grim struggle. Not only is the percentage of cures greater than with any other form of treatment, but the time required to bring about this result is greatly shortened. This is of the utmost value in extensive cases.

For **alopecia areata** many writers have claimed ultra-violet rays as an infallible cure. It is certainly a valuable remedy in many cases, but to speak of it as a specific remedy is to show a lack of knowledge and experience of the disease. The disease is very capricious, and the last remedy—and the last doctor—always get the credit of the cure. Dermatologists have been using the mercury vapour lamp in the treatment of this condition for twenty years, and I am certain that not one of them would deny that many cases fail to respond at all, even after prolonged treatment. There is no doubt that many cases do well under the treatment, but I have seen quite a number getting steadily worse even under vigorous ultra-violet radiation treatment. It is, nevertheless, a remedy to be tried, but the possibility of complete failure must be kept in mind. In alopecia areata the doses must be sufficiently great to produce a brisk reaction on the scalp. The redness ought to be allowed to pass off before another dose is given. In complete baldness it is useful to treat the head in sections at intervals of two or three days rather than the whole scalp at one sitting.

For **furunculosis**, especially in its chronic form, ultra-violet radiations are useful. Patients with this condition are generally much below par and a course of general radiations tones them up and enables them to overcome the infection. The remedy is of much more value in patients who have successive crops of boils than in whom there is only one large one.

In **sycosis** the results of radiation treatment are similar to the results of other forms of treatment, sometimes very gratifying, sometimes very disappointing. Here again the superficial rays are useless, though some workers hold that they are of value in this condition. The organisms lie deep in the hair follicles and the short bactericidal rays cannot possibly reach them on account of their lack of penetrating power. It is putting the patient to unnecessary discomfort to give an exfoliating dose, as is sometimes advised, apart from it being of no value in the treatment of this disease, and it is by increasing the patient's resistance to the staphylococcus and raising his general condition that improvement is brought about.

Psoriasis is another disease in which brilliant results have been claimed for radiation treatment by non-dermatological writers, but no dermatologist ever seems to have attained such results. I have tested the effect of the radiations in several cases, smearing the one side of the body with ointment so as to prevent the rays acting on that side, the other side being left without any such protection. There was no doubt that the side receiving the radiations twice a week, with ordinary treatment on other days, paled more rapidly than the side receiving ordinary treatment only. Other cases, however, have failed to respond and some even get worse under the treatment. The cases which respond best are the ones in which the patches are thin; when

the patches are thick they are more resistant. This is what happens with other remedies also, the indurated cases being resistant to all remedies. In stubborn cases, however, the remedy is well worth trying.

Sometimes the effect is peculiar. On one occasion I was asked to undertake the treatment of a man with large indurated patches of psoriasis on which ordinary treatment seemed to make little or no impression. The radiations had apparently just as little effect and I advised him to discontinue the treatment. He resumed treatment with the ointment which he had been using without any benefit for a month before beginning radiations, and within a fortnight he was about 50 per cent. better. Evidently the radiations had in some way altered his skin and caused it to respond to an ointment which had had no obvious effect previously.

Ordinarily for psoriasis I give doses short of that required to produce an erythema, as the disease may be spread by provoking a brisk reaction on the healthy skin. Even the exfoliating dose to isolated patches is frequently without much effect, and the end-results, as judged by relapses, are no better with radiation treatment than with any other form of treatment. At the same time, it is much cleaner than greases and patients sometimes prefer it to ointments on that account, while fully realising its limitations.

In **herpes zoster** little, if any, advantage is gained by radiating to try to clear up the vesicles. If the time taken as the result of the technique given by various writers is worked out, it is seen that there is practically no difference in the time required for the vesicles to dry up under radiation treatment than under other forms of treatment. It is frequently said that radiations will abort the disease, but this is difficult to prove. Not infrequently the initial pain is

severe, and yet only a few abortive vesicles appear. If such a case had been radiated, the treatment would have been given the credit of preventing the eruption appearing, while the fact of the matter is that there would have been few vesicles in any case. It is for the pain that so frequently accompanies or follows this condition that radiations can be employed with benefit. Even after only one or two doses the patient is able to get better sleep and in this way a considerable benefit is conferred, especially in old people. When the pain persists after the eruption has disappeared, radiations may also be employed with benefit, but the treatment has to be more prolonged than when the pain accompanies the onset of the eruption and radiations are given at that time. The dose need not be exfoliating, but short of that required to produce an erythema. If too severe a reaction is provoked, the benefit may be lessened as the irritation of the skin may prevent the patient getting satisfactory sleep.

In **lupus erythematosus** radiations must be employed with caution. It is well known that sunlight not infrequently aggravates the disease, though in some cases it is beneficial. For this reason the effect of the initial doses of ultra-violet rays must be carefully watched and the treatment stopped at the first sign of deterioration. Local doses short of producing redness may be given in conjunction with general radiations. Some cases do very well, but on no account should radiations be given to a patient who is receiving injections of a gold preparation for this disease.

Burns as a rule do well with radiations. The pain is rapidly soothed and healing promoted under this treatment. Needless to say, if the burn is severe or extensive, the ordinary remedies against shock will have to be employed and it is equally necessary to

remove all dead skin before radiation treatment is given. All ointments or other dressings which are impervious to the rays should be avoided and the best dressing would appear to be liquid paraffin. A thin even layer of this is applied to the surface and then the burn is radiated, a mild dose being given. After the exposure, gauze soaked in liquid paraffin is applied.

Pruriginous dermatoses as a rule react satisfactorily to radiations. One must be careful, however, not to provoke redness, otherwise the itching is distinctly aggravated.

Pruritus vulvæ and **pruritus ani** may improve under radiation treatment for a time, but as a rule the results are not so satisfactory as those obtained with X-ray treatment.

In cases of **dermatitis** or **eczema** an attempt must be made to discover the cause. It is obviously unlikely that radiation treatment, or indeed any other form of treatment, will cure the condition if the cause of the dermatitis is still allowed to act. It must be remembered that dermatitis or eczema is not an entity, but rather a group of symptoms. As our knowledge advances, more and more conditions are being removed from what Sir Norman Walker calls "the rubbish heap of eczema." Many cases of the epidermophyton variety of ringworm, to quote one example, are still diagnosed as dermatitis, and unless this and other recent advances in dermatology are kept in mind, mistakes in diagnosis and treatment will occur. In dermatitis and all other skin conditions it is hardly necessary to say that the ordinary regime which one would employ with other forms of treatment must be carried out, diet, etc., being strictly attended to.

There is no doubt that many cases of dermatitis can be helped by radiations. The acute cases as a rule are not suitable for this form of treatment, although

Lomholt[96] reports good results in acute eczema from concentrated arc light treatment. The chronic cases are the most suitable for radiations. When no obvious cause can be found, it may be that they are kept going by faulty metabolism, and the radiations would seem to alter this and cause them to respond frequently in a gratifying way. One case will illustrate this. A doctor who had a moist dermatitis of his hands for years was sent to me for radiations. He really wished to instal apparatus for himself and came to me for advice as to the type he should procure. On seeing his condition, I informed him that radiations might not be in the least helpful, and suggested that I might give him some treatment and see the response before he decided to get apparatus for himself. While under my care he used a simple ichthyol paste dressing which he had been applying previously. This was done to eliminate any possibility of a different application being responsible for any improvement or deterioration in the skin condition. By the time he had had thirteen doses his skin was completely well and has remained so since he completed his treatment two years ago.

While far from recommending that radiations should be given to every case of dermatitis, I do think that where the condition has resisted proper treatment, it is worth while trying the effect of ultra-violet radiations.

There is one type of dermatitis which does repay the time and trouble given to it in treating it with ultra-violet rays, and that is the red moist scalp with extensions of the inflammation down behind the ears. These cases are frequently due to streptococcal infection, and are most resistant to ordinary treatment, and general combined with local radiation treatment as a rule brings about a marked improvement. Treatment must be prolonged, however.

Chronic neurodermatitis, where the focus of infection responsible for the disease cannot be found, not infrequently responds well to radiations. The dosage should be carefully regulated and be short of producing an erythema, otherwise the itching will be made much worse.

Lomholt[97] reports good results in *chronic dry eczema* from concentrated arc light treatment. He also has had good results in *chronic weeping eczema.*

Infantile dermatitis frequently does very well with radiations. The dosage must be carefully and slowly increased as the itching becomes aggravated on the slightest provocation. Recently Huldschinsky[98] recommended the use of silver nitrate in conjunction with radiations. He paints the affected part with a 5 per cent. solution of silver nitrate and immediately afterwards radiates this part of the skin. After a short time the skin on which the silver nitrate has been painted becomes brown or black. Should a part not become black, he repaints it with silver nitrate and continues the radiations. At the end of the process the whole part becomes black and dry. The itching stops almost immediately, usually after the first irradiation. The following day the blackened parts become scaly and peel off, fresh skin appearing under them. The duration of the treatment is varied, sometimes one week, sometimes several being required.

Pityriasis rosea is a disease which normally clears up in about six or eight weeks even without treatment, but there is no doubt that its disappearance can be hastened with ultra-violet radiations. Hazen[99] suggests an erythema dose. He advises a trial dose to the body and in the light of the reaction the next dose, sufficient to produce slight redness, given about a week later can be judged. He finds that one such dose is

sufficient to clear up the eruption. This condition, however, is frequently wrongly diagnosed and before credit is given to the radiations one must be certain that the diagnosis is right.

Erythema pernio is a condition in which one gets as a rule excellent results from radiations. Soon after treatment is begun the itching becomes less and the lesions gradually subside and disappear. General treatment is the best for this condition.

Erythrocyanosis crurum feminarum is a condition which has become common during the years since the War. At first the lesions were observed just above the ankles, but as skirts became shorter the condition became more extensive and lesions were observed well up the leg towards the knee. While the cause is not known, there is no doubt that cold plays an important part in the production of the disease. Under general radiation treatment the general circulation is improved and the large cold chilblain-like lesions on the legs disappear and the appearance of the skin becomes more normal. All treatment is useless, however, if the patient persists in wearing thin stockings.

Ulcus cruris is frequently associated with varicose veins, but this is not invariably the case. The causes of ulcers of the leg are numerous and it is obvious that these causes ought to be sought for and treated. All ulcers of the legs with the presence of varicose veins are not necessarily varicose ulcers. Not infrequently varicose veins are present on the legs of patients with syphilitic ulcers, and it is obvious that no beneficial results will be obtained from any local treatment if the general syphilitic infection is not treated at the same time. If the ulcer is due to varicose veins, it would hardly be worth while giving radiations for the ulcer and leaving the veins untreated. If this were done

and the ulcer healed, it would almost certainly mean a recurrence sooner or later. This has been the weak point in the treatment of these ulcers previously, but now with the injection treatment of varicose veins it is possible to remove the stasis which is so liable to interfere with the proper healing of an ulcer. If the ulcer is due to an injury in a debilitated person, with subsequent pyogenic infection, it is hardly to be expected that much progress will be made if only local treatment be given and the debility left untreated. It will thus be seen that mere haphazard radiation of the ulcer will not achieve much.

In all chronic ulcers, whatever the cause, the skin round about the ulcer is blue and unhealthy, and before healthy epithelium can be expected to grow at the edges of the ulcer, the skin from which the new cells grow ought to be in a healthy and vigorous condition. If it is not, the new epithelial growth can hardly be vigorous and the end-result will be unsatisfactory.

In the treatment of ulcers, whatever the cause, I believe that general radiations should be given as well as local applications. This applies to hospital out-patient work, at all events. In many of these cases the general condition is below par, and the general radiation treatment will improve the health of the patient and give the ulcer a better chance of healing than if local radiation treatment alone were given.

Large doses producing a brisk erythema must be given locally to obtain beneficial results. Indeed, Weinbren [100] gives to the actual ulcer fifteen to twenty times the dose required to produce erythema on the patient's normal skin and an erythema dose to the skin in the neighbourhood of the ulcer.

X-ray ulcers are benefited by radiation treatment, but in these cases it is advisable to give smaller doses

in view of the damage done by the X-rays to the surrounding skin. If this skin be given too vigorous a dose, sloughing may result and the patient's condition be made much worse.

Bedsores frequently heal up as the result of ultra-violet radiations. Here only mild erythema doses should be given to the ulcer and surrounding skin. If a brisk reaction is produced there will be irritation and discomfort and the patient will tend to rub and scratch the part. As patients with bedsores are usually markedly debilitated, such interference may infect the unhealthy skin round the ulcer and cause it to break down and increase the size of the bedsore.

Trophic ulcers respond well to radiations, but here a brisk local reaction is desirable.

Erythema induratum as a rule benefits from radiations. When the nodules have broken down, X-rays on the whole give better results, but in the earlier stages ultra-violet rays do well. General treatment should be given, with a larger dose locally to the affected areas.

In **dermatitis herpetiformis** good results are obtained, the patient often remaining free from the eruption for months. This is especially valuable in those cases which are controlled otherwise only by the administration of arsenic. In such cases ultra-violet rays can be given during the periods when the arsenic has to be discontinued.

It has been shown that the **telangiectasis** due to X-ray treatment can be benefited by ultra-violet radiations. Lane,[101] Hazen,[102] and others have recorded cases in which improvement in the appearance of the scar was brought about. These observers used local applications only, but even general radiations can cause a reduction of the disfigurement. A lady whom I was

FIG. 14.—Leucoderma in a Lupus patient showing marked Pigmentation round Leucodermic Patches which are uninfluenced by the Radiations.

treating for lupus vulgaris had marked telangiectasis on the arm as the result of prolonged X-ray treatment administered elsewhere for her lupus. After several months' general radiations, I observed that the blood-vessels were becoming less noticeable and the skin of the arm much whiter. I drew the patient's attention to the fact, and she remarked that she herself had observed the difference. Lane advises caution in doses as superficial ulceration may be produced and be so slow to heal as to arouse suspicion of malignant change. He also advises the avoidance of areas of dense scarring and pigmentation because of the possibility of causing necrosis in the former and of stirring up melanotic changes in the latter.

It is sometimes stated that **leucoderma** benefits by treatment with ultra-violet rays. This has not been my experience. The following case is interesting in this respect. A patient who had lupus on her face was sent to our Light Department for treatment. During the course of her treatment it was discovered that she had leucoderma, as the trunk, apart from the leuco-dermic patches, pigmented freely, causing the white areas to stand out distinctly. The woman had not been aware of the presence of the white patches till the rest of the skin became pigmented. There was no change in the appearance of the leucoderma although the radiation treatment for her lupus was steadily continued. The appearance of the spots after several months' radiations is seen in Fig. 14. It has been suggested that the painting of leucodermic patches with oil of bergamot in addition to radiations has a beneficial effect on the condition, but there has been no improve-ment on this patient's leucoderma after the combined treatment for seven months. It is possible that these cases of apparent leucoderma which have benefited

from radiations, have really been cases of pityriasis versicolor. Kistiakovsky[103] has shown that the spots of this disease remain white while the rest of the skin reddens and becomes pigmented. Later, the diseased parts become pigmented also and it is quite possible that some of these cases have been mistaken for leucoderma.

It is frequently advised that other conditions such as **acne** and **ringworm**, both of the head and body, should be treated with ultra-violet radiations. With regard to acne, I do not deny that patients who are having treatment for tuberculosis in one or other form and who have acne, find that it clears up under the radiations. It ought to be remembered, however, that the course of treatment for tuberculosis is a long one and much more extended than would be justified if the acne alone were being treated. If there is much pustulation, there is no doubt that radiations will reduce it. Most writers, however, advise ultra-violet radiations in papular acne and give exfoliating doses. Such treatment will certainly improve the condition, but the same results can be obtained at a fraction of the cost by the use of a peeling paste, and I do not think it justifiable to put the patient to the expense of a course of radiations when ordinary treatment can do the work as satisfactorily.

Ringworm of the scalp should never be treated with ultra-violet rays. The fungus lies deep and cannot possibly be reached by the bactericidal rays. The method advised by non-dermatological writers seems to aim at the deliberate production of an inflammatory reaction. As such a reaction cannot be controlled, kerion may easily result and a permanent bald patch be left. If inflammation is not produced the treatment cannot have any effect. Dermatologists frequently have

had to treat by X-ray or thallium epilation cases of ringworm which were supposed to have been cured by ultra-violet radiations.

As ordinary ringworm of the body clears up in about a fortnight under proper treatment, there would appear to be no justification for treating it with ultra-violet rays.

In the same way, **impetigo contagiosa** as a rule clears up in a week. If it does not, the diagnosis is wrong or the treatment is not suitable, or if suitable, has not been properly carried out. Very occasionally, however, cases are observed in which the resistance to the causal organism is low on account of debility from lack of proper nourishment or some such cause. In these cases radiations are very beneficial, because they raise the tone of the body and the resistance to infection. In this way the impetigo is benefited but it is really the debility which is being treated, not primarily the impetigo. It is hardly justifiable to treat ordinary cases of this disease with radiations, as it clears up so quickly under proper treatment.

Many other conditions, such as **keloid** and **naevi**, have been treated with ultra-violet rays, but as there are frequently other methods available which give better results, or as good results with less trouble and expense to the patient, radiation treatment is hardly to be advised.

The treatment of such ordinary conditions with ultra-violet rays when better results can be obtained by the use of other remedies can only have the effect of bringing radiation treatment into disrepute, but surely the limit of absurdity has been reached when it is claimed that **scabies** can be cured by means of ultra-violet rays. This has actually been claimed by medical men, radiations twice a week being advised and the

parts being treated seriatim when the eruption is generalised. As scabies can usually be cured in three days by other remedies, it is surely futile to advise radiations. Such a practice cannot be too severely condemned.

There is one use for ultra-violet rays in ringworm of the scalp and that is in diagnosis. A filter of Wood's glass is sometimes used for this purpose. Wood's glass contains oxide of nickel and cuts out all rays above 3650 Å.U. It is, therefore, opaque to ordinary light. When such a filter is interposed between the source of radiation and a child's head in a darkened room, the ringworm hairs fluoresce a brilliant green while the normal hairs do not. A single stump will show and even if broken level with the scalp it will still fluoresce. If there is vaseline on the head, it fluoresces and even when removed with ether a little remains in the mouth of the follicle, but according to Roxburgh [104] it is still possible to distinguish the infected stumps. There is a risk, however, of overlooking ringworm if one relies entirely on this method, as Wigley [105] has pointed out that hair fully infected with endothrix ringworm fails completely to fluoresce, apparently because the cuticle of the hair is intact.

Goodman [106] has used a filtered ultra-violet light to try to differentiate different skin conditions and has recorded some interesting observations. He has found it possible to detect an alteration in the appearance of the skin immediately after irradiation with a water-cooled mercury vapour lamp. In white people he found that the degree of erythema which appeared to the naked eye after the latent period, was proportional to the degree of fluorescence shown by the ultra-violet filter. He believes that it will be possible to forecast in a similar way the threshold of action of X-ray and

radium dosage. These observations are interesting, but it is too soon yet to say what importance they possess.

In some cases, Wood's glass can be of value in revealing an eruption which is not visible in ordinary light. According to Meyer and Saidman,[107] sometimes in pruritus there may not be anything seen under Wood's light, but in other cases an intense and generalised eruption is evident; many macules are seen in a network which seems due to varicositics. Those who have shown this phenomenon, have presented eczema lesions a few days later. The same writers have stated that in syphilis eruptions frequently show under Wood's glass though invisible in daylight.

In the field of **venereal diseases** the radiations have a limited use. Soukhareff[108] reports favourable results in the treatment of **soft chancre** by ultra-violet rays. Soon after the beginning of treatment the pain ceased, the œdema diminished and the discharge lessened. Murero[109] found ultra-violet rays beneficial in **suppurative inguinal adenitis** from venereal ulcers. It is chiefly in the sloughing or septic venereal lesions that radiations are useful, except for their beneficial effect in the debility which accompanies syphilis.

An interesting observation was made by Rasch,[110] who reported the case of a young woman whose body was covered with a papular syphilitic eruption up to the line of the covered portions of the body. Where the skin was sunburned there was no eruption. It might be possible by means of ultra-violet rays to prevent the eruption becoming apparent to others, a thing highly desirable in certain circumstances.

In the treatment of **infectious diseases** also, the rôle of ultra-violet radiations is limited, **erysipelas** being the only disease in which there seems to be a

beneficial result. Ude [111] states that his results are very successful, not being duplicated by any other method.

Radiations have been found useful in clearing up the throats of *carriers of the diphtheria bacillus.* Cases have been recorded where patients still carried virulent organisms five months after having the disease and in spite of many forms of local treatment. A few doses of ultra-violet rays locally to the throat were sufficient to render them free. Formigal [112] reports the case of a child whose throat became clear after nine doses, while Petit [113] records the case of a man whose throat was free a week after the fourth treatment, though just before the first irradiation the result had been positive. It is not possible to say whether the results were due to the local action or to the general effect on the body, or both.

While there is perhaps little scope for radiations in the treatment of infectious diseases, apart from the treatment of the debility resulting from such illnesses, there is a new and interesting field opened up in the detection of certain of the **exanthemata**. Wadsworth and Misenheimer [114] observed that the rash of **measles** was visible under the ultra-violet rays after it had ceased to be seen by the naked eye, and—of more importance—also before it was so detected. In fourteen cases it was seen from thirty-three to seventy-six hours before it appeared in the ordinary way, the average being fifty hours. It is present somewhat earlier in blondes than in brunettes, and in babies than in older children and adults. In a case of **scarlet fever**, the eruption was seen plainly eleven hours before it became visible to the naked eye. They are of opinion that exposure would show the coming eruption very early in syphilis. Investigation along these lines may prove to be of value when one is dealing with an outbreak of measles or scarlet fever in an institution.

CHAPTER X

TUBERCULOSIS

Value of Heliotherapy. Reasons for different opinions as to Value of Ultra-Violet Radiations. Gland Tuberculosis. Type of Case most Suitable. Combination of Ultra-Violet Rays and X-rays. Abscess formation during Treatment. Bone and Joint Tuberculosis. Genito-Urinary Tuberculosis. Pulmonary Tuberculosis.

UNDER this heading comes many varieties of tuberculosis, and all forms are not equally amenable to radiation treatment. In this chapter tuberculosis of the skin will not be dealt with, as it has already been described in the chapter on skin diseases, nor will tuberculosis of the eye and of the ear, nose, and throat. These are more conveniently discussed in the chapters devoted to these specialities.

Bernhard and Rollier on the Continent and Gauvain in Britain have been largely responsible for our knowledge of the value of heliotherapy in the surgical manifestations of tuberculosis, and to show its value in this connection one cannot do better than quote Rollier [115] who states: "More than twenty years' experience with heliotherapy in the treatment of surgical tuberculosis, permits us to affirm that this treatment realises to the highest degree the aims of orthopædics and conservative surgery. It enables us to dispense with surgical intervention, so often the cause of irreparable mutilation. By preserving the maximum of articular function, developing the musculature and

restoring to the body the harmony of its outlines, it gives back to the world individuals no longer maimed and deformed, but normal and vigorous and capable of working for their living. Thus heliotherapy acquires, for this reason alone, an incomparable social value." He also states[116] that on the basis of 15,000 to 16,000 X-ray photographs he affirms that no closed bone lesion, whatever its depth or gravity, escapes the curative action of the sun. He avoids occlusive things such as plaster, and states that in his 300 cases of tuberculous peritonitis he had never to resort to laparotomy. His cases admittedly were treated in the best of conditions and with natural sunshine, but Reyn[117] claims that the results at the Finsen Institute are brilliant and as good as those obtained by Rollier working under much more favourable conditions. He instances cases of tuberculosis of the ankle-joint where Rollier registered 92 per cent. as cured. The Finsen Institute show a percentage of 89 cured and these cases include tuberculosis round the talus (astragalus) which has a less favourable prognosis than osteitis of the calcaneus (os calcis), tarsus, and metatarsus, which Rollier includes in his figures. In tuberculosis of the elbow-joint the cures by Rollier are 66 per cent., while the Finsen Institute cures are 83 per cent. The table on pp. 126-7 shows the results in Reyn's cases, and it will be seen that the results as regards the mobility of the joints are very striking and in marked contrast to the loss of function which so frequently follows surgical intervention.

The results of various workers in Britain have been somewhat contradictory. In many cases it is impossible to judge because data as regards type of lamp, type of carbon, and dosage employed have not been furnished. It is sometimes forgotten that the treatment of tuberculosis in any form must be prolonged and the longer the

duration of the disease the more prolonged will be the course of treatment required to produce a satisfactory result. If too much is expected of the remedy in the way of a rapid cure, it is hardly the fault of the remedy if this result is not realised. Time and patience must be devoted to the treatment.

While this may partly explain the contradictory results, it must be admitted that frequently there is something wrong with the technique. Recently I had to see a girl who had a patch of tuberculosis of the skin of the ear. She had been treated for two years at a sanatorium, where she had had local applications of a mercury vapour lamp. No other treatment was applied and the dose rose from two minutes to thirty and then for some reason, which I am afraid is not very obvious, it gradually diminished again to two minutes. It is not a matter for surprise that the disease showed no sign of clearing up, but was still very active. Treatment with ordinary remedies, apart altogether from radiations, ought to have made some impression on the condition in that time, indeed in the six weeks that have elapsed since she first attended the Skin Department, there has been a considerable reduction in the swelling of the lobe of the ear, and no radiation therapy has been employed. It seems possible that the radiation technique in this case has been greatly at fault.

There is no doubt in the minds of a large number of clinicians that ultra-violet radiations are of great value in the surgical manifestations of tuberculosis. In the Report of the Scottish Board of Health it is stated [118] that cases that have dragged on for months and years without making progress have responded rapidly to treatment by irradiation. In view of the results at the Finsen Institute there is no need for discouragement,

Table showing Results in Closed Uncomplicated Cases,

	Number.	Over 15 Years.	Duration beyond 6 Months before Light Treatment.	Changes in Skiagram.	Recovered.		
					Free Mobility.	Partial Mobility.	Without Mobility.
Closed Uncomplicated Cases.							
Dactylitis	22	5	1	20	22	...	...
Tuberculosis of wrist	23	19	19	21	16	3	...
,, elbow	17	12	9	16	9	4	2
,, shoulder	7	7	5	6	3	2	2
,, ankle	14	8	10	9	9	1	4
,, knee	42	28	34	24	15	7	5
,, hip	7	2	3	5	1	1	3
,, spine	7	5	4	4	4	...	...
Tenosynovitis	8	7	6	...	1	...	...
Peritonitis	8	4	5	...	6	...	...
Genito-urinary tuberculosis	3	3	...	...	2	...	...
Cases Complicated with Fistula or Abscess.							
Dactylitis	56	21	29	47	41	5	3
Tuberculosis of wrist	24	22	21	21	6	12	1
,, elbow	31	23	23	24	10	17	3
,, shoulder	8	6	8	8	1	4	2
,, ankle	33	26	30	29	14	12	2
,, knee	14	11	14	12	1	1	7
,, hip	15	12	15	10	...	4	4
Tuberculous disease of ribs and sternum	32	29	24	4	23	...	...
Osteitis (60 patients)	73	47	62	38	68	...	...
Pelvic osteitis	11	8	10	5	6	...	...
Tuberculosis of spine	20	16	16	5	11	...	...
Subcutaneous tuberculosis	42	30	23	...	37	...	...
Tenosynovitis	8	7	8	...	7	...	...
Peritonitis	7	2	7	...	4	...	...
Genito-urinary tuberculosis (female)	6	6	6	...	4	...	...
Genito-urinary tuberculosis (male)	16	16	11	...	12	...	...

and Cases Complicated with Sinuses or Abscesses.

Improved.	Unchanged.	Died under Treatment.	Treatment abandoned by Patient.	Controlled.			Relapses.	Cured later.
				Total.	Over 1 Year.	Over 3 Years.		
...	...	...	...	21	8	8	...	...
2	1	...	1	21	8	13	1	1
...	2	...	...	14	7	5	...	...
...	...	...	...	7	5	2	...	...
...	...	...	...	13	7	3	...	...
2	8	1	4	29	10	11	5	1
...	...	...	2	5	1	3	1	...
1	...	...	2	4	4	...	...	...
...	7	...	...	...	...	...	...	...
...	...	...	...	6	1	3	1	...
...	1	...	...	2	1	1	...	...
...	...	1	6	9	26	14	4	2
1	1	...	3	18	9	2	1	1
...	1	...	...	22	13	6	5	4
...	1	...	...	6	2	1	2	2
2	...	2	1	30	14	11	1	...
2	2	...	1	9	3	6	2	...
...	5	1	1	8	2	4	2	...
...	5	...	4	23	11	6	4	...
2	1	1	1	68	41	13	2	2
...	3	2	...	6	1	2	...	...
1	3	3	2	11	7	2	1	...
2	1	...	2	36	26	7	...	...
...	...	...	1	5	3	...	...	...
1	2	...	...	4	3	1	...	...
2	...	...	...	6	2	3	2	1
2	...	...	2	12	6	4	...	...

and every effort ought to be made to reduce the number of cripples and comparatively helpless people who suffer from surgical affections of a tuberculous nature.

Tuberculous glands are very common and the results of surgical treatment far from satisfactory. Too often glands recur after operation, another operation is performed and not infrequently there is a further recurrence. If recurrence at the operation site does not take place, it is often found that soon afterwards groups of glands at different areas enlarge and the last state of the patient is worse than the first. The extirpation of the first group of glands seems to have removed the immunising influence which results from the slow and gradual absorption from the glands. Rollier [119] regards a cold abscess as a depot of antibodies which contributes in great part to the immunisation of the patient, and deprecates its premature puncture. That glands have this immunising influence is shown by the results of injections of prepared gland tissue. In the Skin Department of the Royal Infirmary early in 1920, injections of such tissue were given to lupus cases. The glands had been taken from patients elsewhere, were ground down and sterilised, and the resulting fluid diluted so that it would pass through a hypodermic needle. These injections gave excellent results in cases of lupus as photographic records show.[120]

Another result of the removal of glands is the infection of the skin. On investigating the figures at the Skin Department of the Royal Infirmary some years ago, I found that 45 per cent. of our cases of tuberculosis of the skin followed glands, and 25 per cent. of the total cases followed surgical intervention. These are minimum figures. I have frequently seen tuberculosis of the skin occur not only in the line of

the incision, but even in the scars marking the stitch holes. Only those who have had to deal with bad cases of tuberculosis of the skin can realise the tragedy behind the lives of many of these patients. There is now little excuse for surgical intervention in glands as in ultra-violet radiations we have a potent remedy, which, in the great majority of cases, will cure the glands satisfactorily. Reyn [121] states that about 95 per cent. of 500 cases of gland tuberculosis have been cured at the Finsen Institute by ultra-violet ray therapy. At present there are under treatment in one of my departments a considerable number of cases where the glands have been removed surgically and where the skin has become slightly infected. These cases were sent for light treatment after operation instead of before operation. Even in many of these cases there has already been a recurrence of the glands though the operation was performed not more than a few months ago. The patients came to be treated in my department only through a fortuitous chance, but as the result of the light treatment they will be spared the appalling disfigurement and misery which would presently have come upon them.

The evidence in favour of treating tuberculous glands by radiations is very convincing. It is too much to expect that every case will clear up rapidly and there must be variations in results just as there are with other forms of treatment, but Reyn's figures quoted above will bear favourable comparison with the results of any surgical treatment. Cameron [122] of East Fortune Sanatorium states: "When one has seen the labours and uncertainty of other methods of treatment, one marvels all the more at the results of this." Even more emphatic is the opinion of Brodie [123] of Wishaw, whose experience is that no matter whether the case came

with a discharging sinus, with the glands softening or in hard masses, they invariably did well under irradiation. His success has been such that he now seldom has gland cases in hospital, as they can all be treated successfully as out-patients.

The type of gland tuberculosis which yields most readily to radiation treatment is that in which there is a mass of glands all bound together and immobile on the deeper tissues. Under radiations the periadenitis becomes less and the individual glands can presently be distinguished. Diminution of the volume follows and eventually the glands disappear, though in some cases little fibrous nodules remain, generally mobile though occasionally bound down by fibrous bands—the remains of the inflammatory reaction round the glands. With the diminution in the size of the gland mass there is usually a steady improvement in the patient's general condition—a marked contrast to the lack of health for months following surgical intervention. The association of doses of X-rays with ultra-violet rays hastens the disappearance of the glands and not infrequently one can clear up in two months a mass of glands about the size of a small orange.

It is hardly credible how soon in some cases the reduction in size occurs. Some years ago I was asked by a surgeon to treat a case of glands in the neck. He had operated some time previously and the glands had recurred. He did not wish to operate again, nor did the mother of the child desire another operation. He warned me that he was not satisfied with the condition of part of the scar and feared that it would soon show signs of suppuration. Treatment was begun on a Thursday and the second dose was given the following day. When the child came on the Monday for the next dose, the mother asked me to look at the girl's

neck. After the surgeon's warning I fully expected to see signs of suppuration. I did not and was a little puzzled at the mother's request, but continued to palpate the neck. At last I remarked that I could not find any sign of pus and that I thought the glands were smaller. The mother at once replied: "That was what I wanted to know. We all thought so, but were afraid to believe that it could be possible."

Less suitable for radiation treatment is the type of gland which is hard, painless and isolated, mobile under the skin and on the deeper tissues. While ultra-violet radiations cause a diminution in volume, the results are inconstant and the treatment has to be more prolonged. In these cases more than in the type previously described one can with advantage give doses of X-rays as well as general ultra-violet radiations. Local doses of ultra-violet rays may also be given, a brisk reaction being provoked. If the treatment is persevered with, a satisfactory result in the end will be brought about.

According to Kinloch,[124] calcification may take place without any reduction in the size of the gland, and this was more noticeable in cases treated with the mercury vapour lamp.

Not infrequently it is found in treating tuberculous glands of the neck that, if there is pus anywhere in the gland, it comes more quickly to the surface under radiations and the patients think that the treatment is making the condition worse. They should be warned that this apparent deterioration may occur and then they are not alarmed. If an abscess does form, it is best treated by aspiration just before it is likely to burst, but it is unwise to aspirate too soon. If necessary the aspiration can be repeated later. It should not be necessary to use a scalpel in treatment of these cases.

In *mediastinal glands* it is found that ultra-violet radiations administered in slowly increasing doses give, in general, satisfactory results. As the treatment progresses, the cough and respiratory trouble diminish and X-ray photographs show a diminution in the volume of the glands.

In **bone and joint tuberculosis**, as would be expected from the action of ultra-violet rays on the repair of bone, the results are very gratifying. The treatment of joint tubercle is becoming more and more conservative. Though the duration of treatment is longer than that required for operative measures, the results of radiation treatment are more satisfactory from the functional point of view, and consequently more desirable from the economic standpoint. In general, it is observed that in the treatment of joint conditions there is speedy relief from pain, the muscles retain their tone, and the sufferer is of an entirely different disposition, cheerful happy children taking the place of fretful, weakly ones. To quote again Cameron[125] of East Fortune: "The degree of healing and restoration is very wonderful. The child with multiple lesions of bones and joints proceeds to results which a few years ago were undreamt of."

In the treatment of bone and joint lesions all encumbrances such as plaster cases should be avoided as far as possible, and where apparatus for immobilising the limb is necessary, it ought to be such that the limb can be irradiated.

In tuberculosis of the *spinal column* good results are obtained, even where there is the disadvantage of having to move the patient to the light room for treatment.

In *hip-joint disease* the results are encouraging. Where they are not so satisfactory it is possible that the observation of Jardine[126] at the City Hospital,

Edinburgh, may explain them. He found that there was an increase of fluid in the joint as the result of exposure to ultra-violet radiations. This tends to compress the artery supplying the head of the femur and so lowers its recuperative power. The acetabular blood supply is also diminished with devitalisation of the cartilage of the acetabulum. If there is clinical evidence of fluid in the joint, he suggests that the fluid should be got rid of. He advises giving smaller doses and states that since he has adopted this plan, he has been getting better results.

Regions where there is a good blood supply respond better than regions where the supply is poor. The *knee* and *elbow* respond very quickly to treatment, as do also the *ankle* and *wrist*. Rollier states [127] that the ankle is of all the joints, with the one exception of the wrist, the most favourable from the point of view of curability. As in gland cases, so in articular tuberculosis, the more recent the infection and the younger the patient, the shorter is the duration of treatment. The duration can thus vary from six months to two years, though in some of the more favourable cases a shorter time is required. Recently there was treated in one of my departments a girl with tuberculosis of the carpal bones. In two months the result was, according to the surgeon who sent her for treatment, marvellous. As this surgeon was previously distinctly sceptical of the value of radiation treatment, the adjective he uses is illuminating.

Tuberculosis of the *tarsal bones* also responds satisfactorily to radiations.

Under the term **tuberculous peritonitis** various forms of the disease are included. The *ascitic* form almost always reacts favourably to radiation treatment. Soon after treatment is begun, it is found that the

diarrhœa becomes less frequent, pain is relieved, and the appetite is improved. Occasionally, however, a resistant case is found in which puncture or laparotomy has to be performed. Jardine[128] suggests that the favourable results in this form of tuberculous peritonitis are due to the immobilising effect on the mesentery of the ascitic fluid which, to begin with, increases in amount and acts as a splint. He only taps when there is very considerable ascitis.

In *tabes mesenterica* the results are gratifying when the infection is localised, the doughy mass getting steadily smaller. When the condition is extensive, a complete cure is less likely to be attained, though in some advanced cases marked improvement may be obtained.

Acute, rapidly spreading tuberculous peritonitis is generally regarded as unsuitable for radiations, but as it is usually a hopeless condition, no harm can be done by radiating carefully such a case.

Intestinal tuberculosis gives variable results. The diarrhœa may cease, the pain become less marked, and the general condition improve, but the treatment does not always cure. Brown and Sampson,[129] working at the Trudeau Sanatorium, give their results in cases where the intestinal lesions were secondary to pulmonary tuberculosis. Of their cases 18 per cent. did not benefit, 33 per cent. were slightly or considerably helped, 25 per cent. markedly benefited, and 24 per cent. apparently cured of their secondary tuberculosis.

In **renal tuberculosis** radiations are not to be given ordinarily. The most satisfactory cases are those in which there is a sinus following removal of a kidney. When both kidneys are involved, it is the only treatment that can be given, and if it cannot effect a cure, it can at least keep the patient in comfort. The bladder

is usually affected in such cases and the radiations help the patient by diminishing the frequency and pain of micturition and the amount of pyuria. The potent effect of radiations in these cases is well shown by Cameron,[130] who had a young adult suffering from genito-urinary tuberculosis who suffered days and nights of pain and who passed into peaceful sleep under the light. His hour of treatment was the one of the twenty-four and he lived for it.

Tuberculosis of the **female adnexa** gives excellent results, while disease of the **testis** and **epididymis** responds in a very gratifying way. The large masses diminish steadily under the influence of the radiations, while fistulæ gradually dry up and close, though there may be a primary increase of the discharge.

In the treatment of **pleurisy with effusion**, radiations may at first increase the amount of fluid, but with continued treatment the fluid tends to become absorbed and a satisfactory result to ensue. One must note carefully, however, the condition of any pulmonary lesion before proceeding to radiate these cases.

It was formerly thought that radiations were contra-indicated in **pulmonary tuberculosis**, and many reports have been published where the criticisms have been adverse to this treatment being employed. It is almost certainly a matter of dosage, and more recent opinion is that, if radiations are carefully administered in suitable cases, good results can be obtained. The bogey has been the fear of hæmoptysis. Some observers, however, do not look even on this symptom as a contra-indication. Schürer[131] does not regard it as one, and he refrains from giving radiations only in those cases with marked cachexia and high fever, those who are too weak to wash themselves, and those with large cavernous or pneumonic processes. This puts a

severe test on the remedy, and yet he found no ill effects in the 63 cases he treated. There was no increase in the quantity of the sputum, and no case showed signs of new foci nor activity in an old one as the result of the treatment.

Gödde[132] reports on the action of a quartz lamp in lung tuberculosis. He points out that the treatment is not without danger, although if properly regulated, it becomes a valuable adjunct to other forms of treatment. In some of his cases there was a reaction with an increase in the physical signs in the chest, but in most of these cases it was well-nigh impossible to determine whether the ill-effects were due to the radiations or to some other factor. He does not consider that a reaction is harmful, but that it eventually leads to an improvement in both the local and general condition. In some cases, however, there was a definite relation between the treatment and the reaction.

The results in intestinal tuberculosis already quoted were obtained in patients with pulmonary tuberculosis, and there is nothing to indicate that the workers there observed any deterioration in the pulmonary condition.

Würtzen[133] of the Finsen Institute states that the fears that only a few phthisical cases could be treated by light on account of the treatment being too fatiguing, have proved unfounded. He has not seen any harmful effects on the temperature. Though some of his cases have shown a rise of temperature after irradiation, he puts this down partly to the general heating of the body by the treatment and partly to the consumptive's unstable heat regulation. He has not seen any loss of weight due to the radiations, nor has he observed any increase in the number of hæmoptyses. He states definitely that the results obtained have seemed so promising to Danish phthisiologists that light treatment

has spread from the Finsen Institute to all sanatoria and all hospitals containing similar cases, and that it has been adopted everywhere as a regular form of treatment. He states that there is no real contra-indication, but that the whole matter is a question of dosage.

E. and H. Biancani[134] state that the cases where there have been signs of a focal reaction have, in their experience been rare, and generally where the doses given have been too great. They believe that there is nothing to fear if the doses are properly regulated and point out that other active remedies are not altogether harmless, and yet have not been condemned on that account. They believe that it is not the extent or degree of the lesions which constitutes a contra-indication to radiations but their nature. If the lesion be actively spreading, radiations should not be given, but in a large number of cases of different types, and at different stages they have had good results.

It will thus be seen that there is a considerable amount of evidence in favour of radiations in pulmonary tuberculosis. Most observers who have given radiations, find that the appetite improves, sleep becomes better, and the weight increases. The cough and expectoration lessen, and the temperature begins to settle and the patient to feel better.

It is possible, however, that radiations are more suitable for patients resident in an institution than for patients being treated by a doctor at his house. The dose must be small and very gradually increased, and under these circumstances the fatigue of going to the doctor's house and undressing for and dressing after the treatment may counterbalance the benefit obtained from the small doses. When the patient can be treated in his own home, where he can rest before and after

treatment, these considerations do not arise. When the disease is quiescent the objections just mentioned do not apply to the same extent, and radiations may more easily be given in the doctor's consulting room.

In every case the dose must be small and the increase be very gradual. The temperature should be taken and marked on a chart, and this should be carefully studied before each dose is given. A slight rise of temperature does not mean that treatment should be stopped. The weight should be carefully watched, and if there is a progressive loss, the treatment should at once cease, though there is sometimes a small initial loss which does not prevent the continuation of the treatment. Needless to say, the physical signs in the chest should be carefully studied, though a slight reaction there does not prevent the treatment being carried on. In the more advanced cases it is perhaps advisable to limit the amount of body surface which is subjected to radiations and only gradually increase the area exposed. If the dosage is carefully regulated and modified according to the needs of each case, there is no reason why phthisical patients should not get the benefit of the treatment which has proved of so much value in other forms of tuberculosis.

CHAPTER XI

DISEASES OF CHILDREN

Rickets. Spasmophilia. Tetany. Malnutrition. Asthma. Bronchitis. Enuresis. Acidosis. Whooping Cough. Splenic Anæmia. Infantile Paralysis. Chorea. Convalescence after Acute Illnesses. The Nervous Child. Special Points in the Radiation of Children.

THE uses of radiations in children are numerous, but first and foremost place must be given to their value in **rickets**. As long ago as 1890, Dr Palm described in *The Practitioner*[135] the value of sunshine in rickets, and more recently Tisdall and Brown[136] have recorded that there is a close relationship between the incidence of rickets and the altitude of the sun, rickets being rare where the minimal seasonal altitude of the sun is not below 35°, and common when the sun's altitude is below 35° for some months of the year.

Much discussion has taken place round the question as to whether diet or light is of most importance in this disease. There is no doubt that lack of vitamin D can cause rickets in children, but it does not do so in adults. The work of Tisdall and Brown would show that lack of light has a great bearing on the production of the disease, while the work of the German Scientific Expedition to the Faroes and Iceland[137] suggests that lack of sunshine is of more importance than lack of vitamin D, as the food in these two places is practically identical, though rickets is common in the former and rare in the latter. The only difference that the

investigators found seemed to be the lack of sunshine in the Faroes due to the prevalence of mist, while in Iceland there was no mist and abundance of sunshine. This observation supports that of Hutchison,[138] who found that the poor children in certain parts of India suffered less from rickets than did the children of the well-to-do, who, though they had better food, were more confined than the poorer children. There must be some other factor, however, otherwise adults suffering from lack of vitamin D or sunshine would develop rickets. It has been suggested by Huldschinsky[139] that the other factor is growth, as the signs of rickets are most severe on those parts of the body where growth is strongest.

Whatever be the real cause of the disease, there can be no doubt that in ultra-violet radiations we have a most potent remedy for the disease. It has been shown that the defective calcification of the bones is associated with diminished concentration of the inorganic phosphorus and calcium of the serum. This lack of these salts in the blood is due to a diminished capacity of the intestines to absorb them, even though they be present in sufficient quantity in the diet. Under the influence of ultra-violet rays, they are absorbed more freely and their content in the blood rises and coincidentally there is a more satisfactory calcification of the bones as shown by X-ray photographs. The general condition of the child rapidly improves even after only a few doses, the muscles become firmer, the child begins to take more food and the weight increases. Sleep becomes better, the hæmoglobin rises and there is an increase in the number of red cells and leucocytes. As the condition improves, the bony signs of the disease become less prominent and are eventually lost. This does not mean, however, that deformities which result from rickets, such as

bow-leg or knock-knee, will clear up. These must be dealt with otherwise. If a child has developed rickets and has ceased to walk, radiations soon bring back the ability to do so, and this is one of the things which most impresses the mother in many cases. Some cases of rickets are more resistant to treatment than others, and these must have a more prolonged course of treatment, but in the case of average severity two or three months will suffice for a cure.

The question of prevention of the disease and also of recurrences is of considerable importance. Many observers, including Huldschinsky, are now of the opinion that relapses are more frequent than was formerly supposed. If this is so, it means that we must not be content merely to clear up the condition for the present. It is well known that the milk which we get from cows in winter is lacking in vitamin D, and this means that it is not possible to rely on milk and butter to protect the child from rickets throughout the winter. Nor is there the sunshine available to help in the fight against this disease. Various ways of protecting the child against the disease have been suggested, but all are open to objections. It has been suggested that irradiated milk should be given instead of ordinary milk, or that ergosterol should be added to it. It is doubtful if these methods of dealing with the matter are entirely satisfactory, and the reasons against the use of such substances will be more fully dealt with in the section on the use of irradiated foodstuffs. The most satisfactory plan at present would seem to be to give the child periodic doses of radiations throughout the winter in the way which has been suggested (see page 102) to protect against colds.

It has been asked if it is not sufficient to give regular doses of cod-liver oil, as this has been known

for many years to be beneficial in this disease. It has been found, however, that many cases do not improve while on cod-liver oil and yet show immediate improvement when radiations are given. Banks[140] found that the results of the administration of cod-liver oil were on the whole poor, and that radiation treatment meant a more striking improvement in the symptoms such as sweating, vomiting, and diarrhœa, than was the case with the cod-liver oil treatment.

It has been said that the mercury vapour lamp is of more value in the treatment of rickets than is the carbon arc, but it is not so. Results which leave nothing to be desired can be got from the arc, and it is interesting to note in this connection that Huldschinsky[141] has recently devised a lamp for the prophylaxis of rickets which approaches much more closely to natural sunshine than does the mercury vapour lamp.

Spasmophilia and **tetany**—conditions which are not infrequently associated with rickets—react in a gratifying way to radiations. The muscular spasms of the hands—the accoucheur's hand or carpo-pedal spasm—yield to the influence of the rays and sometimes quickly. One of the most satisfactory features is the rapid cessation of the laryngeal spasms which are so alarming. The vomiting which is so frequently seen in this condition, rapidly disappears, and the general condition of the child begins to take on a different aspect.

In the more severe cases of the disease when there are actual convulsions, the same good results are seen, the number of attacks becoming rapidly less, and each attack becoming less severe, till they cease altogether.

The treatment should be continued till all signs of nervous irritability have passed away, and may have

to be prolonged if there is an accompanying severe rickets. One point in treating this condition must be remembered, and that is that the spasms may become more frequent for a few days after the commencement of treatment.

Cases of **malnutrition** and **marasmus** do well as a rule. Infants who have no apparent disease, but who do not thrive, begin to improve almost at once. If diarrhœa and vomiting are present, these cease, the appetite begins to improve, and the weight increases. Even when the weight remains stationary for a few weeks, the appearance of the child is quite different. Instead of lying limp and listless, he begins to move his limbs in the active way a healthy child should, and the skin takes on a shiny look which is in marked contrast to the dull unhealthy appearance it had before treatment was begun. Similar gratifying results are also obtained in premature infants.

In **asthma** in children, even where all other remedies have failed, ultra-violet radiations not infrequently bring about a great improvement. As treatment progresses the attacks become fewer and less distressing and in many cases what is practically a cure is brought about. Even where this cannot be obtained, the smaller number of attacks and the lessened severity of these is by no means to be despised and much relief can be given in this way.

Children who suffer from attacks of **bronchitis** are very suitable for radiations, especially if the bronchitis is troublesome during the winter. In such cases a course of radiations before the bad weather begins may keep the child comparatively free during the rest of the winter. The following case is illustrative in this respect:—

A. W., a boy of 9, was in the habit of suffering from bronchitis regularly throughout the winter. After a

bad attack his doctor sent him for a course of radiations. He had fifteen doses altogether and the result was so gratifying that some ten months later the doctor informed me that he had not had to attend the child for bronchitis since his course of treatment, though previously he was being called in frequently to see the child.

Even more striking is the case of a boy of 6 who had had attacks of bronchitis almost without intermission over a period of nine months. His parents had been advised to have him given a course of radiations, but they declined to do so. Finally with the continuation of the attacks, they consented five months after the treatment had been first advised. The result more than exceeded their expectations. The boy had four weeks' treatment and has not been in bed with an attack of bronchitis during the two years that have elapsed since he had the treatment. He has had slight attacks of catarrh, but has not had a real attack of bronchitis.

In **enuresis** the results are inconstant, quite a number of cases showing no improvement. Gamgee,[142] however, thinks that the results with radiation treatment are on the whole more satisfactory than with any other form of treatment.

Children suffering from **acidosis** are suitable for radiation treatment, improvement being observed after even a few doses. Reference may be made to the case quoted on p. 81, where there was a gain of 4½ lb. in weight in two weeks and two days.

Whooping cough is another disease in which radiations ought to be given. Many observers hold that the spasms of coughing are reduced in number and violence. Even when there is no appreciable diminution during the day, it is usually found that they are fewer during the night, especially the latter part of the night. The

value of a considerable spell of unbroken sleep cannot be too highly rated, as it assists the recuperative capacity of the child.

Splenic anæmia benefits from radiation treatment. Careddu [143] gives the results of treatment in twelve cases in which a syphilitic, tuberculous, or malarial etiology was excluded. In all the cases there were more or less marked signs of rickets, and in nine cases he proved the existence of malarial infection in the mother or both parents and in the grandparents. He believes that there is a general or partial constitutional defect involving the hæmopoietic organs. Treatment with ultra-violet rays, when carried out for a long period regularly, effected considerable improvement in the hæmopoietic and general conditions in seven out of the twelve cases, in the other five the rapid evolution of the disease could not be influenced and intercurrent broncho-pneumonia led to a fatal termination. In these cases, however, treatment was taken irregularly and during short periods of time.

Cases of **infantile paralysis** seem to be definitely benefited by radiations, but the treatment should be commenced as soon as the acute stage has passed.

Chorea also benefits by radiation treatment in conjunction with the ordinary treatment for this condition, but the improvement appears to be more rapid with radiation treatment than when ordinary treatment alone is given.

In the **convalescence** after broncho-pneumonia and all acute illnesses radiations are indicated. Soon the little patients lose their white, wan faces, appetite increases, weight is put on, they commence to take an interest in their games and playthings and they are restored to health much sooner than they would otherwise be.

The "**nervous child**" as a rule benefits greatly from a course of radiations. Appetite becomes less capricious, the mother reports that the fits of temper are fewer and sleep is much sounder.

The mention of the nervous child leads to the discussion of one or two special points in regard to the radiation treatment of children. Not infrequently it is rather difficult to get such a child to allow the goggles to be put on for its first treatment. In a clinic where many children are being treated, the difficulty is not as a rule so great, as the new child sees some of the older patients. In private work, however, occasionally one meets with considerable difficulty at first. It is of course not possible to switch on the lamps before the child has its goggles fastened, and it is just because the child cannot see through the goggles that it is afraid. I am strongly opposed to tying up a child's eyes, even though the child is not particularly nervous, and such a practice is, in my opinion, wrong in the case of nervous children. If the goggles can be held on till the lamps are switched on, the child begins to quieten down almost at once as a rule, especially if the mother or nurse stays and holds its hand. There is no use struggling with a child who refuses to allow the goggles to be tied on. Such a procedure only makes the child afraid to come back again. In such a case, I generally allow the child to sit astride its mother's knee, with its head close against her body. In this way the child has its back exposed and when it realises that it is not going to be hurt, it usually allows the goggles to be fixed on. I have found it of considerable advantage in dealing with young nervous children, and also with older children, to bribe them into allowing the goggles to be tied on, by promising to give them some gramophone music. This promise, I have found, generally

quietens them sufficiently to allow the goggles to be applied, and I have only once found a child continue to refuse to have the goggles on. A stock of nursery rhyme records is a great asset in dealing with some of these children, and I have had children singing heartily to the records though a few minutes before they had been resisting with tears all attempts to put their goggles on.

CHAPTER XII

ULTRA-VIOLET RADIATIONS IN SURGICAL CONDITIONS

Post-Operative Debility. Delayed Healing of Wounds. Acute Appendicitis with General Peritonitis. Sinuses and Fistulæ. Skin Grafts. Un-united Fractures. Phlebitis. Ischio-Rectal Abscess.

WHILE it is in tuberculous affections that ultra-violet radiations have their greatest scope surgically, their value is not limited to these conditions. There is no doubt that **post-operative debility** yields readily to radiations and the return to full health and strength is greatly accelerated. Even when the patient appears to recover satisfactorily from the operation, there is frequently a lack of vitality for some months afterwards. A change to the country in such circumstances in winter is of little or no value and in ultra-violet radiations an alternative is offered and one which will produce a more satisfactory result.

Another use of radiations is where there is **delayed healing of a wound** after an operation. It may be that the patient's strength has been sapped by long illness preceding the operation, or that there was a suppurative condition present which prevented the wound being closed. It may be that the incision had to be made through unhealthy tissues, and on this account fails to heal in spite of all ordinary treatment.

Whatever the cause, the patient should be given

radiations as soon as possible after the operation. In this way the general condition will be improved and the operation wound will close more quickly and more soundly.

If the condition has been one of the skin and subcutaneous tissues, the indurated red mass gradually alters its appearance, the hardness diminishes and finally disappears, while the appearance of the wound itself becomes progressively more healthy and a satisfactory result is achieved.

If the operation has been an abdominal one and the wound delays in healing, not infrequently adhesions form in the abdominal cavity and occasion the patient a great deal of suffering for the rest of his life. Subsequent operations to free the adhesions are not satisfactory. If such a patient had had radiations as soon after the operation as possible, the plastic peritonitis giving rise to the discharge would have resolved quickly, and the formation of adhesions with their subsequent results would have been prevented.

That these cases would benefit greatly by early radiation treatment is shown by the striking results which are obtained in cases of **acute appendicitis** with **general peritonitis**. These cases when sent to the light treatment room as soon as possible after operation react in a very gratifying way, and some surgeons have found this treatment of such value that they send such patients for radiations as early as the fourth day after operation.

Sinuses frequently close under the influence of the rays and this is the case whether the sinus follows an abdominal operation or a condition such as osteomyelitis. At first the discharge may become more profuse and the patient ought to be warned about this, but presently

it becomes more fluid, then diminishes in quantity and finally dries up.

Fistulæ can in the same way be benefited by ultra-violet radiations. It is rather unfortunate that in these conditions so many surgeons delay sending the patient for radiation treatment, many looking upon it as a last resource. The longer the delay before treatment is instituted, the more difficult it is to heal up the sinus or fistula. It is a pity that ultra-violet ray treatment could not be looked upon as an ordinary part of the treatment, just as the changing of the dressing is. Generally speaking, it may be said that if a wound delays in healing or does not heal by first intention, the patient ought to be given radiation treatment as soon as he can be moved to the treatment room. Even in these cases where removal to the light room is impossible, it is still possible to have radiations administered as there are many varieties of portable apparatus available. If this procedure were regularly carried out, the patient's condition would speedily be improved and the formation of a sinus probably be prevented. It is fair neither to the patient nor to the remedy to wait six, twelve, eighteen months or more before advising ultra-violet radiations and then expect the sinus to close in a few weeks' time. Sinuses following empyema are more stubborn, and I would strongly suggest that such patients should be given radiations as a routine as soon as possible after the operation in view of the marked disability which the condition causes.

In all the conditions above mentioned, general radiations should be given, but local treatment can with advantage be added especially when a definite sinus has formed, doses sufficient to provoke a reaction being given to the wound and the parts surrounding it.

In this way a local stimulation is produced while the general radiations improve the general health of the patient.

Skin grafts can be benefited by local radiations. In this way the taking of the graft is favoured and the number which die is diminished.

From what has already been said about the effects of radiations on phosphorus and calcium metabolism, it might be expected that ultra-violet radiations would benefit cases of **un-united fractures**, and this is amply borne out by clinical experience. As soon as it has been decided that there is delayed union, radiations should be given, as in this way not only are the reparative processes stimulated and the union of the fragments hastened, but there is also a better functional result as the immobilising apparatus can be more quickly discarded, thus allowing massage and movement to be more quickly instituted and muscular atrophy and ankylosis accordingly avoided.

Savini[144] gave ultra-violet radiations to a man suffering from **phlebitis** of the femoral vein following appendicitis. He recovered almost entirely, being able to walk five weeks after beginning the treatment. There had previously been no improvement under the usual remedies for five months.

Ischio-rectal abscess does well with radiation treatment. Even when operations have been performed on more than one occasion, the result of ultra-violet ray treatment is beneficial. The following is an illustrative case:

Mr MacK. had been operated on for ischio-rectal abscess eleven months previous to being sent for radiation treatment. He had had a recurrence of the condition, but did not wish another operation, and the surgeon advised ultra-violet radiations. These he

received thrice weekly, general and local radiations being given. The sinus was healed after six exposures, but he continued the treatment till he had had eighteen doses in all. It is now three years since he finished the treatment and he has had no recurrence of the condition.

CHAPTER XIII

DISEASES OF THE DIGESTIVE SYSTEM. DISEASES OF THE RESPIRATORY SYSTEM. DISEASES OF THE CIRCULATORY SYSTEM

Colitis. Atonic Constipation. Coryza. Bronchitis. Broncho-Pneumonia. Asthma. Hyperpiesis. Radiations in Arterio-Sclerosis. Angina Pectoris. Raynaud's Disease. Acro-cyanosis and Sluggish Circulation. Chlorosis. Secondary Anæmias. Pernicious Anæmia. Purpura. Hæmophilia.

THE indications for ultra-violet ray treatment in **diseases of the digestive system** are few, but **colitis** is a condition in which excellent results frequently follow a course of radiations. The following is an illustrative case:—

Miss A. had had colitis for about three years. It was so troublesome just before coming for treatment that she had seriously contemplated resigning her post as a teacher. She had a three weeks' course of treatment and felt much more fit at the end of it. She had put on $2\frac{1}{2}$ lb. in weight and could eat food which previously she could not take on account of her colitis. Diarrhœa had ceased to trouble her and her general condition had improved to such an extent that she no longer contemplated resigning her post. She has been in much better health since her course of treatment than she had been for a considerable time before it.

In what are commonly known as bilious attacks where no apparent cause can be found for the trouble,

great benefit can be obtained from radiations. The following is an illustration:—

Miss L. had had two or three bilious attacks per week for some months previous to having ultra-violet ray treatment. No cause had been found for these attacks and she was sent for treatment on account of the debility resulting from them. She had a bilious attack the night she commenced treatment, and no further attack during the three weeks' course of radiations. When seen sixteen months later she stated that she had had only three attacks since she finished her treatment, and on two of these occasions the attack was due to the ingestion of some substance which she knew she should not have eaten.

Where **constipation** is due to an atonic condition of the bowels it is frequently found that benefit results from radiations, the bowel muscle partaking in the rise of tone of the body generally.

In **diseases of the respiratory tract** only a few indications for radiation treatment exist. There is no doubt that an incipient cold in the head can frequently be cut short by one or two doses of ultra-violet rays. Even when the cold is fully developed and the catarrh is passing to the bronchial tubes a few doses not infrequently will arrest it completely.

Reference has already been made (see page 97) to the beneficial effect of radiations in persistent cough. No effect can be expected in **emphysema**, but the **bronchitis** which accompanies it, is usually helped by a course of radiations. The patient finds that the cough becomes easier and his night's rest is less disturbed. In chronic bronchitis patients find as a rule that a course of radiations early in the winter tends to delay the onset of the bronchitis, and to make

it less severe than it generally is. The following case well illustrates the relief which can be obtained :—

Mr M. had been troubled with chronic bronchitis for many years. Before the treatment his condition was so bad that his night's rest was being greatly disturbed. He would waken about 4 o'clock in the morning and would cough more or less steadily for the rest of the night. This interfered with his sleep, the result being that his health began to deteriorate. After he had had only three doses of ultra-violet rays, he reported a considerable improvement. He wakened about the same hour, had a bout of coughing, then went to sleep again and slept till about 7 o'clock. By the time he had finished his three weeks' course of treatment, his cough was much less troublesome, his sputum was considerably diminished, sleep was very satisfactory, he had put on 2½ lb. in weight, and felt much more vigorous.

Broncho-pneumonia can frequently be benefited by ultra-violet radiations, even where there is a considerable rise of temperature. Sleep improves, the patient is more restful and feels more inclined to take the food allowed, while the temperature becomes more and more reduced till it reaches normal. The dose must be considerably smaller than that given in non-febrile cases. When there is delay in the resolution of the broncho-pneumonic patch, radiations hasten its disappearance.

Opinions vary markedly with regard to the value of radiations in the **asthma** of adults. Some cases seem to do well, the attacks becoming less frequent and less violent. Other cases seem to be entirely uninfluenced. This is not to be wondered at, as the causes of asthma are many and varied, and it can hardly be expected that the same remedy will influence all cases beneficially, but the same is true of all other

remedies for this condition. It is, however, such a distressing complaint that ultra-violet radiations are worthy of a trial.

In **circulatory disorders** little help can be expected from radiations. It has been said that uncompensated heart disease is a contra-indication to radiations, but this is not my experience. I have had occasion to treat several patients for other conditions though they had cardiac trouble and have not found any bad effect on the heart condition. No improvement, however, could be expected on the cardiac condition as the result of the treatment.

In **hyperpiesis** a definite lowering of the blood-pressure can be obtained as the result of radiations and that without any skin reaction. It is, indeed, quite unnecessary to provoke redness to obtain a reduction of the blood-pressure, and in many cases it occurs before the time has elapsed for the skin reaction to show. Hyperpiesis is frequently associated with arterio-sclerosis, and it may appear inadvisable to radiate patients in whom the two conditions are present. Arterio-sclerosis, however, is not a contra-indication in my experience. Sonne has shown that radiations destroy toxins, and mention has already been made (see p. 36) of the reduction of blood-pressure that occurs in pre-eclamptic cases as the result of radiations. This is probably due to a similar destruction of toxins. Hyperpiesis is not infrequently associated with faulty metabolism, the circulation of toxins in the blood giving rise to the increase of blood-pressure and eventually to arterio-sclerotic changes in the vessel walls. It is possible that the fall of blood-pressure that takes place soon after radiation, is due to the destruction of these toxins. In addition to this, the radiations can influence the faulty metabolism and bring it back more closely

to the normal. Under these circumstances ultra-violet rays will be beneficial in hyperpiesis even when there is an associated arterio-sclerosis.

Cases have been reported in which good results have been claimed in **angina pectoris** from ultra-violet radiations. Freund [145] found that the pain disappeared and the patient was able to dispense with the use of nitro-glycerine. He states that it is necessary to produce a definite reaction up to an acute dermatitis, the front, back, and the left side of the thorax being treated. A statement that a condition such as angina pectoris is benefited by radiations, must be accepted with a certain amount of reservation and caution. According to Mackenzie,[146] angina pectoris is a sign of a failing heart muscle, and under these circumstances it is not to be expected that benefit can be derived from radiations in this condition. Until more experience has been gained, it would be wise to refrain from advising radiations for angina pectoris.

In **Raynaud's disease** and **acrocyanosis** there would appear to be no doubt of the beneficial action of ultra-violet radiations. Relief is given soon after the treatment is begun, and as the course progresses this relief is more lasting. Such patients are very susceptible to cold, but soon after treatment is commenced, they state that they feel the cold much less acutely. The circulation improves and the cyanosis disappears. Even after the course of treatment is finished such patients feel the cold less keenly than they did formerly.

There can be no doubt as to the benefit to be derived from ultra-violet radiations in **chlorosis**. The hæmoglobin definitely improves and the red cells increase in number. Concurrently there is an improvement in the patient's general condition, the pallor, breathlessness, and lack of energy disappearing.

Secondary anæmias respond rapidly. Hobert[147] found that the regeneration of the blood after bleeding with loss of 50 per cent. of the red corpuscles, was complete in thirteen to fourteen days with exposure to light.

The anæmia following serious illnesses benefits also in a marked way from radiation treatment. The following is an illustrative case :—

A. C. had had a septic throat following enucleation of tonsils and was gravely ill with a hæmolytic streptococcal septicæmia. After he had recovered to a certain extent he developed a streptococcal dermatitis of his right hand. This would not clear up in spite of ordinary treatment, his general condition being so poor. He refused to go away for a holiday until the skin condition was cleared up. He was given light treatment, and before he had had ten doses his dermatitis had completely gone though it had persisted for six or seven weeks before radiation treatment was begun. His hæmoglobin increased from 65 per cent. to 80 per cent. in less than a fortnight, and his general condition was quite different. Further improvement would have continued under radiations, but as his hand was now cured, he had no excuse for not going to the country, and I stopped the treatment as he promised to go away to the south of France a day or two later.

Good results have been reported in **pernicious anæmia** from radiations. It might seem that with the liver treatment now available light treatment is unnecessary, but a quicker response in the general condition of the patient is obtained. Macht and Anderson[148] have shown that the toxic reaction of pernicious anæmia blood serum is diminished when such serum is irradiated in a quartz tube. Such

detoxification of the serum also occurs as shown by the same test after exposure of patients with pernicious anæmia to ultra-violet rays. Ultra-violet radiations in a series of patients treated by these observers have been followed by an improvement in their general condition. This improvement is not only indicated by the subjective and objective amelioration of symptoms and a marked improvement in the blood picture, but also goes hand in hand with a diminution in the toxicity of the blood which in their opinion seems to point to a destruction or inhibition of the causative factor in the disease.

In **purpura** and **hæmophilia** good results have been recorded by some observers, but others have not obtained any improvement. With the increase in the calcium content of the serum and the increase in the number of the blood platelets as the result of radiations, benefit might be expected in these conditions. In view of the contrary results, however, which have been recorded, no definite opinion can be passed till more experience has been gained in the treatment of these conditions.

CHAPTER XIV

DISEASES OF THE NERVOUS SYSTEM

Neuritis. Sciatica. Neurasthenia. Insomnia. Neuralgia. Mental Diseases.

In some **diseases of the nervous system** ultra-violet radiations can be of great benefit. **Neuritis** is one in which the results are frequently most striking. In most cases there is an exacerbation of the pain for forty-eight hours after the commencement of the treatment, but after that the pain rapidly lessens and frequently is completely gone within a week, even though the neuritis had lasted for years previously. One case will illustrate this :—

Miss R. had had neuritis in her right forearm for years. It prevented her from sleeping and was rendering her useless for her household duties, as articles would fall from her hand without any warning. Her teeth had been X-rayed and the photographs of the abdomen showed that there was no intestinal stasis. No cause could be found for the neuritis. She came to me for ultra-violet radiation treatment for marked debility following influenza and bronchitis. For the first two days after the commencement of treatment the neuritis was much worse, in fact it became so bad that she had little sleep and she was afraid she would have to give up the treatment. She was reluctant to do so, however, because of the debilitated condition for which she had come for treatment and decided to

persevere a little longer. After the third dose the pain in the arm began to pass off and by the end of the first week it had completely gone and she was knitting vigorously—a thing she had not been able to do for years. Though it is now more than three years since she had her treatment she has had no return of the neuritis, though she has not had any subsequent radiations. This shows that the effect of radiations is not a fleeting one, as some people try to make out.

Sciatica behaves in a similar way, the pain being worse for forty-eight hours or so and then rapidly clearing up. There is no need to radiate the skin over the nerve as the effect is systemic, not that of a counter-irritant (see p. 46). One word of warning must be given. If the sciatica is due to pressure, radiations will not benefit it. It is in the toxic or rheumatic form that improvement can be expected from radiations.

Neurasthenia is another nervous condition in which benefit can be derived from radiations. The patient sleeps more soundly and presently commences to take an interest in things other than himself. The treatment in these cases should be more prolonged than is necessary for ordinary tonic purposes, and it is desirable to keep the dose short of that producing an erythema on account of the effect it would have on the patient's sleep.

Insomnia is a condition in which good results are frequently obtained from radiations. The following will illustrate the benefit which not infrequently is received :—

Mrs J. suffered from insomnia and head pains due to worry over family affairs. Her sleep was so bad that hypnotics had been ordered, but as she did not

seem to improve, her doctor advised her to have ultra-violet radiations. At her first visit she asked if she should continue to take the hypnotics and I advised her to stop them if she could possibly do so, as in that way we would be more able to determine whether or not the radiations were benefiting her. At the end of the first week's treatment she was disappointed because she was not sleeping any better than she had been previously, but I reminded her that she had stopped the hypnotics and yet was getting, as she admitted, as much sleep without them as she had been previously getting with their use. During the second week's treatment she began to sleep on the couch soon after the lamps were switched on and remained fast asleep for the rest of the exposure. In spite of this sleep in the middle of the afternoon, she began to sleep better at night, and before the end of the third week's treatment she was sleeping soundly all night long in addition to and in spite of the short sleep in the afternoon while having her treatment.

Even cases of acute insomnia can be benefited, though the response is not so rapid.

Neuralgias also yield to ultra-violet radiations as a rule in a most satisfactory way.

Radiations have been used in other conditions such as **disseminated sclerosis** and **locomotor ataxia**, but it is doubtful if they have any real effect. Such improvement as may have occurred may have been due to a natural remission of the disease. The best that one can say at present is that the patient's general condition may be improved by the tonic effect of the radiations.

In the realm of **mental disease** radiations have been used with benefit, many alienists recording good results from their use. Dods Brown[149] recently gave

his experience in more than 200 cases treated in this way. In many of these the prognosis of the mental disease was unfavourable, but a large proportion of the patients derived decided benefits. Most of them gained weight and there was an improvement in appetite, muscle tone, sleep, and blood picture. His results in **acute** and **simple melancholics** were disappointing. In some **chronic melancholics** improvement began with the treatment though they had been in hospital more than five years without showing any such improvement.

Cormac [150] found cases of **manic-depressive insanity** responding readily, the period of depression being curtailed, but he found melancholia aggravated by the treatment, nor did he find any improvement in dementia præcox.

CHAPTER XV

GYNÆCOLOGY. DISEASES OF THE DUCTLESS GLANDS. RHEUMATIC DISORDERS

Chronic Gonorrhœa. Adnexal Inflammation. Erosion of the Cervix. Pre-Eclampsia. Osteomalacia. Menorrhagia and Metrorrhagia. Amenorrhœa. Dysmenorrhœa. Pregnancy and Lactation. Diabetes. Exophthalmic Goitre. Obesity. Rheumatism. Rheumatoid Arthritis. Lumbago. Muscular Rheumatism.

IN **gynæcology**, apart from tuberculous conditions which have already been dealt with, there are several conditions which can be benefited by ultra-violet radiations. **Chronic gonorrhœa** may subside completely, the applications being made locally as well as given to the general surface of the body. In this condition, as in all gynæcological conditions where local applications are given, the Gallois high frequency electrodes are of considerable value. These electrodes are quartz tubes containing an attenuated atmosphere of mercury vapour. They are operated from an ordinary high frequency generator or diathermy set and give the combined effect of high frequency applications and mild ultra-violet radiations.

Colombino and Mozzetti-Monterumici[151] report favourable results in cases of **exudative adnexal inflammation** of septic or gonorrhœal origin. Of ten cases treated, the subjective and objective symptoms disappeared in five, three patients reported symptomatic improvement, while two were unaffected.

They also obtained favourable results in **chronic cervicitis** and **leucorrhœa.**

Recasens[152] reports excellent results in **erosion of the cervix**, **simple cervicitis** and **papillary vegetations**, while **woody phlegmon** of the **broad ligament** has yielded to light baths in a remarkable manner.

Radiations have been used with benefit in **bartholinitis**, and some cases of **chronic metritis**, while some observers have reported good results in cases of **salpingitis.**

Mention has already been made of the effect on blood-pressure in pre-eclamptic cases, and various authors have recorded similar results. Mayer[153] found a reduction of blood-pressure equal to 3-4 cm. of mercury, but he found no change in the albuminuria nor œdema. He thinks that the ultra-violet rays have the effect of diminishing the acidosis which seems to be the origin of the eclamptic state. Hochenbichler,[154] on the other hand, found a diminution of the albuminuria but not the œdema. He found radiations useful, even after the onset of convulsions. Of 100 cases treated in the early stages, none developed serious complications.

Osteomalacia is a disease which is characterised by softening of the bones. While it is not common in this country, it is serious because of the effect on the pelvic bones of women and the consequent difficulty in confinement. As one would expect from the resemblance to rickets, this condition benefits considerably from ultra-violet rays.

Menorrhagia and **metrorrhagia** are also benefited by radiations. This is what one would expect as the result of the calcium changes in the blood due to ultra-violet radiation. On one occasion I had to treat a patient for post-influenzal debility. She had, in addition, a marked menorrhagia, and during the course of her treat-

ment her period came on, but the flow was much less free and of shorter duration than it had been for months before.

In **amenorrhœa** beneficial results are frequently obtained from radiation treatment. The benefit may be brought about partly by the improvement in the blood condition when the amenorrhœa is due to anæmia and partly by the effect on the ovarian secretion. Not infrequently the menstrual flow returns within a month of the treatment being commenced.

Dysmenorrhœa is regularly relieved by ultra-violet radiations, but this result cannot be expected if the dysmenorrhœa is due to a mechanical cause such as a displaced uterus.

In **pregnancy** benefit can be obtained from radiations. Apart from the tonic effect on the woman, it is frequently found that the vomiting of pregnancy is checked. The effect on the child is entirely beneficial, as indeed one would expect.

It is not infrequently found that a **nursing mother** benefits from ultra-violet radiations. This is especially the case if she is run-down. The radiations tone up her general condition and a better flow of milk is brought about. Even when the mother's condition seems satisfactory, the milk supply sometimes fails, and in such a case radiations not infrequently cause a freer secretion and enable the mother to continue to nurse the child instead of having to wean it.

DISEASES OF THE DUCTLESS GLANDS.

The stimulating effect of radiations on the **internal secretions** is seen also in cases of **diabetes.** Mention has already been made of the effect of radiations on the dosage of insulin required, and observations suggest that the reduction brought about is due to the stimulation of the pancreas to secrete more insulin.

The **thyroid gland** is also influenced by ultra-violet radiations. In **exophthalmic goitre** the radiations have a beneficial effect, the patient being calmed by the treatment. The general condition tends to be improved and the patient becomes more vigorous. In cases of exophthalmic goitre, however, great care must be taken in dosage as these patients are very sensitive to radiations, and a vigorous reaction can be produced even by small doses.

The **parathyroid glands** would also seem to be stimulated by ultra-violet rays, as cases have been reported in which beneficial results were obtained from radiations in post-operative **parathyroid tetany**.

Obesity not infrequently is reduced as the result of radiations. It may seem strange that this should be the case when so many people put on weight as the result of treatment, but the explanation is quite simple. Metabolism is stimulated and more complete combustion of the food ingested results; consequently none is deposited as fat, some of the latter being called upon to help in the metabolic process. It will be evident, however, that no effect can be expected from radiations when the obesity is due to over-indulgence. It is rather when there is endocrine gland dysfunction or metabolic disturbance, that reduction in the obesity can be obtained.

Rheumatism not infrequently can be greatly helped by radiations. The pain becomes less, movements become freer and the stiffness diminishes. The following case illustrates the improvement which can take place:—

A doctor's wife who was coming for treatment for a surgical condition informed me after she had had about a fortnight's radiation that she surprised herself running downstairs, whereas before commencing treatment she

had had to go downstairs slowly, bringing both feet on to the one step before proceeding to the lower one. As I had not known that she suffered from rheumatism, this statement as to the improvement which had taken place in that condition as the result of less than ten doses was the more gratifying.

In **rheumatoid arthritis** the range of movement is sometimes greatly increased as the result of radiations, as the following will show :—

An elderly lady with rheumatoid arthritis of the spine and knees was sent to me for treatment. The range of movement in her right knee was through an angle of less than 30 degrees. After she had had a few doses, I began to move her knee at the end of her exposure and found that it was with difficulty and a certain amount of discomfort to her that the limb could be straightened. By the end of the third week she had complete flexion and extension without any discomfort whatsoever. Her spinal stiffness cleared up also. At the beginning of the course of treatment she had to be assisted from the supine to the sitting position, but within a week she was able to sit bolt upright without any assistance.

Even when the joint is so much affected that the range of movement cannot be increased, benefit can be obtained in the shape of relief from pain. Many patients find that the pain is so much lessened that any movement which is possible can be accomplished without much effort or discomfort, and in other cases the night's rest is more satisfactory because of the disappearance of the pain.

Lumbago frequently yields in a striking way, and many patients who are practically helpless one day can move freely within three days. This benefit can be obtained even without producing an erythema. In

some cases I have seen the patient rise with difficulty from a chair in my waiting-room to come through to my consulting-room, and yet get up with comparative ease from the chair on which he sat to obtain the treatment. On one occasion a patient who had come for a tonic course of radiations, complained after a few doses that as the result of a wetting on that particular day, he was suffering from an attack of lumbago and that that meant at least three weeks' discomfort for him, as he was rather subject to that complaint and that was the usual duration of his attacks. I informed him that I would cut short his attack, and I gave him a rather larger dose than I would have given in the ordinary course of treatment. The following day the lumbago was no better as he had again been thoroughly soaked at his work, and he once more affirmed that it meant a three weeks' bout. I gave him another big dose, and on the occasion of his next visit he informed me, when I asked him how his lumbago was, that he had thought I was too optimistic in saying that I would cut short his attack, but that I had been perfectly right as his lumbago was completely gone.

Muscular rheumatism of other parts reacts in a similarly favourable way to radiations. In these cases I prefer to give general radiations with a rather larger dose to the affected area.

CHAPTER XVI

DISEASES OF THE EAR, NOSE AND THROAT. DISEASES OF THE EYE

Aural Tuberculosis. Chronic Otitis Media. Delayed Healing after Mastoid Operation. Lingual Tuberculosis. Laryngeal Tuberculosis. Value of Local Light Treatment. Tuberculosis of the Nasal Cavities. Rays that affect the Eye. Ultra-Violet Rays and Cataract. Chronic Styes. Chronic Blepharitis. Chronic Conjunctivitis. Keratitis. Iritis. Corneal Ulcers. Corneal Opacities. Scleritis.

In diseases of the **ear, nose and throat,** ultra-violet radiations are chiefly of use in cases of tuberculosis, though their value is not limited to these affections. There can be no doubt of their value in these tuberculous conditions as Strandberg, Plum and others have shown.

Aural tuberculosis as a rule does well. Of Strandberg's[155] series of cases operation was avoided in twenty-three instances. In forty-one cases where operation and light treatment were carried out, only nine ears did not dry up.

Chronic otitis media as a rule does very well with radiations. General radiation should invariably be given, but local treatment may be carried out in addition.

After **mastoid operations** it is not infrequently found that there is delay in healing, and as in other similar surgical conditions, general and local ultra-violet radiations are a valuable help in bringing about the

lessening of the discharge and the healing of the wound. Early radiation is highly desirable in these cases.

Lingual tuberculosis, especially when there is ulceration, responds well to radiation treatment and the ulcer commences to show signs of healing though it had previously resisted all forms of treatment for many months.

Cases of **laryngeal tuberculosis** also respond satisfactorily. A good deal has been written about treating laryngeal tuberculosis by ultra-violet rays reflected on to the part. This seems to be of little value, and in any case is quite unnecessary. Apart altogether from the discomfort to the patient of having to keep the mouth open for a considerable period, it is very doubtful if the diseased part receives any appreciable amount of light as even the best of mirrors reflect only about 50 per cent. of the incident ultra-violet rays. There is also the difficulty in reflecting the light accurately on to the affected part and keeping it there during the whole of the time required for the exposure, and it is probable that any benefit received from this procedure is due to the irradiation of the fauces.

All cases of laryngeal tuberculosis are suitable for light treatment, even the very severe exudative types which are always complicated by pulmonary tuberculosis in various stages.

Of Strandberg's [156] 435 cases of rhino-laryngeal lupus, cures were obtained in 86·6 per cent., and some of the patients had not had any relapses during a period of observation lasting ten years.

Even where the disease is too advanced to hope for a cure, the patient's condition is improved, because the pain and difficulty on swallowing disappear quickly under the influence of general radiations. This disappearance of pain and difficulty is one of the greatest

advantages of light treatment in this condition, and all observers are agreed about the relief given by the treatment.

In some cases the results are not so satisfactory on account of untimely surgical intervention, according to Plum.[157]

The following case illustrates the improvement which can be brought about by general light baths :—

Miss R. was referred to our Light Department from the Ear, Nose and Throat Department. She had laryngeal tuberculosis and could speak only in the merest whisper. She was given general light baths only, and after a few weeks' treatment there was a distinct improvement in the voice. By the end of three months the voice was back to normal except for a slight hoarseness due to the scarring of the vocal cords. She continued treatment and the throat condition cleared up entirely. She has now been off treatment for about three years and there has not been any signs of recurrence. She reports periodically both at our department and the Ear, Nose and Throat Department, and the surgeon there is perfectly satisfied with her laryngeal condition.

Tuberculosis of the nasal cavities is common and not infrequently is the starting-point of the skin infection. A considerable number of our cases of lupus of the skin of the nose have intranasal lupus and they are periodically examined by the staff of the Ear, Nose and Throat Department on that account. These cases do well on general light baths without local radiation treatment. In other cases other local treatment is employed, as in this way the duration of treatment may be shortened. That general light baths will suffice to cure intranasal lupus has been shown by Strandberg.[158] He treated patients who had lupus of the inferior

turbinate bone solely with light baths. After all the clinical symptoms had disappeared these bones were removed, and it was shown by a series of sections that there was no sign of tuberculosis left.

DISEASES OF THE EYE.

Ultra-violet radiations may be successfully employed in several eye conditions, but before mentioning these it might be of value to describe the rays which affect the different structures of the eye.

According to Duke-Elder,[159] the cornea absorbs completely all heat waves longer than 20,000 Å.U. For all practical purposes the lower limit of transmission may be taken as 3000 Å.U., the rays below this being responsible for exciting inflammation of the cornea and conjunctiva, the most potent being from 3000 to 2500 Å.U. Above the 3000 Å.U. level a steadily increasing percentage of rays is transmitted to the underlying lens and iris. The lens absorbs all radiations below 3200 Å.U. and practically all below 3500 Å.U. Above this the amount absorbed diminishes till the level of 4000 Å.U. is reached, all the rays above that being transmitted by the lens and reaching the retina.

Radiation for eye disease may be general or local. In direct radiation of the eye great care must be taken to prevent the rays reaching the lens and producing cataract. Burge[160] has shown that if a lens, after exposure to ultra-violet radiation which left it still clear, be immersed in certain salt solutions which left the normal lens unaffected, it turned opaque. The important practical point to be realised is that while the rays may not induce at the moment any apparent change in the lens, yet a definite change is brought about and only becomes manifest as cataract when a certain state of body health occurs. It cannot be too

strongly insisted that ultra-violet rays will not cure cataract, but on the contrary may produce it, though this latter statement is not agreed to by Hoffman,[161] who states that up to the present it has not been proved experimentally that ultra-violet light may cause cataract.

According to Duke-Elder,[162] harm may be done by radiating the eye in acute stages of disease, but much benefit may be obtained from radiations if these are given before the condition becomes chronic and before the lesions become complicated by the accumulation of massive organised deposits. It is in the more severe, the chronic and the recurrent forms of eye trouble that the greatest benefit seems to be derived from radiations.

In all forms of eye disease the dosage for general radiations would seem to be that which produces a slight erythema.

Chronic styes can be greatly benefited by general radiations. I have known a case where vaccines improved the condition, but did not cure it. A holiday following the vaccines failed to clear up the styes which became numerous again after the return from holiday, but they cleared up entirely in less than a fortnight with radiation treatment.

Chronic blepharitis does well with radiations, as also does **chronic catarrhal conjunctivitis. Spring catarrh** as a rule yields readily to radiation treatment.

All forms of **tuberculosis of the eye** respond usually to radiations, and in all these cases radiations should be given. As these are the eye conditions which are most resistant to ordinary treatment, it is the more gratifying that they should do well with ultra-violet rays.

Tuberculous irido-cyclitis, tuberculous keratitis, and **uveitis** can as a rule be greatly improved or cured by radiation treatment, though Lundsgaard[163] found tuberculous keratitis unsuitable for treatment.

Some forms of **conjunctivitis**, such as *phlyctenular conjunctivitis*, respond readily and clear up in a gratifying manner. **Keratitis**, both *interstitial* and *phlyctenular*, frequently do well.

In some cases of **infectious irido-cyclitis**, **sympathetic ophthalmitis** and **choroiditis**, excellent results have been claimed by Duke-Elder,[164] who has recorded gratifying results also from local radiations in cases of **corneal ulcer** and **hypopyon ulcer**. **Chronic ulcers** may frequently be made to heal over and remain quiet after a course of three, four, or more exposures to light. The same author has had encouraging results also in **iritis** and **chorio-retinitis**. Good results also are obtained in **trachoma** by local radiations.

Claims have been made that corneal opacities will clear up under radiations, but Duke-Elder[165] found no results to justify this. He found, however, that recent opacities such as those following ulceration, may be improved and the prophylactic action of the treatment of ulceration by light in the prevention of opacity formation is very marked.

Some cases of **scleritis** respond well to radiations. The following is an illustrative case :—

Miss T. had had scleritis for six years. It was most troublesome during the winter, and was interfering with her work as a teacher. She had fourteen exposures during the autumn, and the scleritis, which had been threatening again to become troublesome, cleared up. The following spring she reported that she had had no trouble with her eyes throughout the winter, in spite of continuous physical and mental strain for a period of three months. As she had found that it was generally under these conditions that the eye trouble started, the result was most gratifying to her.

CHAPTER XVII

ABUSES OF RADIATIONS. RADIATIONS IN DENTISTRY. RADIATIONS IN VETERINARY SURGERY AND POULTRY FARMING. OTHER USES OF RADIATIONS. IRRADIATED FOODSTUFFS. GLASSES PERMEABLE TO ULTRA-VIOLET RAYS

It is too early yet to say what are the limitations of ultra-violet rays in the treatment of disease, but unfortunately abuses have begun to creep in and the remedy is being used indiscriminately. Many people who are not in the least qualified to use the remedy, are employing it in the treatment of disease and not infrequently without any knowledge of the diseases which they are treating. Radiations are being used for conditions which are better treated by other remedies, and the ordinary remedies are often not given a proper trial before radiation treatment is instituted. This, unfortunately, applies to medical men as well as to others. Recently the Representative Meeting of the British Medical Association[166] passed a resolution that a register of persons qualified to give the treatment should be compiled, but no specifications were made as to who was to be the judge of what constituted proper qualifications. The mere possession of a medical degree does not qualify a person to use a remedy in the use of which he has not had special training, and which if improperly used can lead to a great deal of discomfort, and may even do considerable damage.

I have on several occasions been asked by doctors to advise as to the type of apparatus they should instal. In the course of conversation it has transpired that they did not know the contra-indications for treatment, and in some cases that they did not know that there were possible dangers attending its use. Under these circumstances, I suggested that they should spend three months at a large general hospital and obtain some training in the use of the remedy.

The Superior Council of Public Hygiene of France [167] have been obliged to look into the question of abuse of ultra-violet rays by charlatans. They have declared that it is necessary in the interests of public health to confine the use of the remedy to hospital services and to authorise its application only by specialist physicians.

Mention has already been made of the misguided enthusiasts who proposed to treat scabies by means of ultra-violet rays, and many claim to cure ringworm of the scalp by the same means. A study of the vast literature on the subject shows that the most fantastic claims are being made, in some cases the writers showing clearly that they do not know the disease they are treating. I have read a paper in which the writer described his treatment of shingles with ultra-violet rays and then went on to describe the treatment of herpes zoster, as though the two diseases were different. Another instance is that of a writer who claimed to cure in a certain number of doses a case of acute neuritis of a week's duration though it had resisted all the ordinary remedies before radiation treatment was begun. How many remedies can a doctor try out thoroughly in a week? Such extravagant claims can only lead to the discredit of radiation treatment.

Some years ago the representative of a firm of manufacturers of ultra-violet apparatus called on me and tried to induce me to purchase one of their lamps. In the course of the conversation he made the statement that most of the doctors who had installed the apparatus were simply playing with it. I was inclined to resent this and asked him if he could give me definite instances where the remedy had been abused or other evidence to justify his statement. He gave me several, one of which I may mention. In a certain large town where his firm had a showroom, a well-known practitioner called and requested to see their lamps. He was shown one, and he next asked how it was manipulated. This was demonstrated. "What is the dose, and for what is it useful?" he next asked. It was explained that it hardly came within the province of manufacturers to say what the dose was and that there were books on the subject which might help him. "I don't believe in the thing," he replied, "but my patients are asking for it and I have to give it to them." I felt my resentment oozing away, as it was impossible to justify such an attitude.

Another thing that leads to abuse is the lack of care in talking of the remedy. Many people speak of the violet rays when they mean ultra-violet rays. I have frequently heard even doctors mention the remedy by the former name. This simply plays into the hands of hairdressers and other unqualified people. These people use a high frequency electrical discharge in a vacuum tube and as this gives rise to a violet or purple colour, this apparatus is called by such people violet-ray apparatus. As high frequency electricity and ultra-violet rays are entirely different and are used for quite different diseases, patients who get the former under the impression that they are getting the latter and find

that they obtain no benefit from it, are much inclined to say that ultra-violet radiations are of no value. In this way incorrect description tends to bring a valuable remedy into disrepute.

For some of the abuse which prevails the manufacturers of some types of apparatus are to a large extent responsible. They have numerous advertisements: "Instal it in your home." "The home of the future will not be complete without its sunshine apparatus"—and the like. If they were actuated solely by their desire to benefit the health of the people, their attitude would perhaps be more excusable, but I fear that we cannot say that they are governed entirely by altruistic motives. The result is that many worthless types of apparatus are on the market, and people who have used them without benefit believe that ultra-violet rays are of no use.

Much more could be said about this part of the subject, but sufficient has been mentioned to show how much the remedy is being abused. As medical practitioners we can help to prevent this abuse both by proper designation of the remedy and by avoiding uncritical enthusiasm of its use.

RADIATIONS IN DENTISTRY.

A considerable difference of opinion exists about the value of ultra-violet rays in **dentistry**. Some dentists praise it almost extravagantly, others say it is of little value. There would seem to be no doubt that after an extraction of a tooth, local radiations relieve the pain and hasten the healing of the gum, but whether or not it will benefit a condition such as pyorrhœa is another matter. It is obvious that the bactericidal rays cannot penetrate the thickness of the gum, so that any beneficial effect which may be

produced must be due rather to the general raising of the condition of the body. If this is the case, one would expect better results from general radiation than from radiation of the gums alone. That a definite focal reaction can be brought about in the mouth by general radiations is shown by the following:—

Miss A. was sent to me for treatment for rheumatism. She was a diabetic and was a difficult person to treat, as apparently the slightest thing upset the sugar-insulin balance. It had been thought that this instability and her rheumatism were due to a root abscess. Her tooth had been extracted with great difficulty and she had had to spend about four weeks in the house after the extraction. It was some four months after having the tooth removed that she was sent for radiations as her rheumatism was not clearing up. After a few general doses she mentioned that there was a definite swelling of the gum round the site of the extraction. As this continued to come and go after each exposure, I advised her to go again to her dentist so that he could satisfy himself that there was no fragment of tooth or spicule of infected alveolus remaining. The dentist stated that he was not surprised at the delay in the healing of the gum, as the tooth had been such a bad one and so difficult to extract. He found no fragment remaining and this was confirmed by X-ray photograph. The swelling persisted, however, and seemed to become more extensive and I was convinced that there was sepsis present. She visited her dentist again and had the two teeth, round which the swelling was, extracted. There was definite chronic inflammation at the root of one and an abscess at the root of the other.

This case shows definitely that a focal reaction can be produced by ultra-violet radiations applied to the

general surface of the body. It also shows that X-ray photographs are not to be implicitly relied on for deciding the presence or absence of apical sepsis. It would suggest that if radiations be given for pyorrhœa, they should be given generally rather than locally, so as to get the maximum benefit due to the larger surface being radiated, and so increasing to a greater extent the resisting power of the body.

RADIATIONS IN VETERINARY SURGERY AND POULTRY FARMING.

In **veterinary surgery** ultra-violet radiations have their uses. It is known that the animal organism is incapable of synthesising vitamins, and is dependent on its diet for them. In cows this explains the difference in the nutritive values of winter and summer milks. Experiments seem to show that more of the substance necessary to cure rickets is absorbed by the cow exposed to ultra-violet rays and secreted in her milk. For this reason cows ought to be exposed as much as possible to sunlight or to ultra-violet rays from artificial sources if the milk is to be used for feeding infants. Apart from this aspect it is desirable to expose them, as it would seem from experiments at the Rowett Institute, Aberdeen,[168] that the irradiation of a lactating goat decreased the loss of calcium and phosphorus from the animal and might even convert it into gain. It is believed in the light of the results of other experimental work on cows that the prevention of loss of calcium and phosphorus from the body during lactation would increase the period of maximum yield of milk and safeguard the health of the heavy milking animal. The results also indicate that irradiation of cows artificially during the winter months might become a practical and profitable procedure.

Perry [169] found ultra-violet rays successful in treating skin diseases, indolent wounds and ulcers, and rickets in dogs. He also treated successfully pneumonia and catarrhal distemper, but had no success in treating follicular mange. The latter is of interest in view of the fact already mentioned that dermatologists have not thought it possible to treat satisfactorily ringworm of the scalp with ultra-violet radiations. I have no doubt that the reason is the same, that the fungus lies deep and cannot possibly be reached by the bactericidal rays.

Some greyhound owners use ultra-violet rays in the attempt to keep their dogs fit, while several notable stables treat their horses with ultra-violet rays as it is considered that horses thus irradiated are brought into better condition during the winter racing season.

In **poultry farming** ultra-violet rays are useful. Workers at Wisconsin University [170] found that irradiation of hens influenced egg production beneficially and that the anti-rachitic potency of egg yolks from irradiated hens was ten times that from non-irradiated hens.

Bovie [171] of Harvard describes an experiment on chickens at the State University of Maine. In a greenhouse from which the plants were removed, 250 chicks a week old were placed. They were divided into three batches. One was allowed out into the open air and only entered the greenhouse for food and rest. The second batch was irradiated daily, while the third batch received only the sunlight as it came through the glass of the greenhouse. At the end of five weeks the chicks of the third batch were only about half the size of the chicks of the first two batches.

This may be of some practical value in poultry

farming, as not infrequently in inclement weather, it is impossible to let the young chicks out. Radiations in such circumstances would be highly beneficial.

OTHER USES OF RADIATIONS.

The field of usefulness of ultra-violet rays is ever widening and now they have a recognised place in **art**, **science** and **commerce**. Ultra-violet rays can be used to prove the authenticity of paintings and detect fakes. When parchments were scarce it was not uncommon for them to be used again and again, the old writing being erased. Filtered ultra-violet rays reveal the latter, which is sometimes of greater importance than the later writings.

Ultra-violet rays are also useful in medical jurisprudence on account of their ability to reveal and estimate minute quantities of arsenic. It is said[172] that it is possible to detect and estimate amounts as small as 0·00001 mg. in this way.

Changes in cheques — invisible in daylight — can be detected and insertions in different inks in wills or legal documents can be rendered visible, while counterfeit money[173] can be proved from the genuine article.

In analytical chemistry ultra-violet radiations are of value in the titration of muddy liquors. To an ordinary neutral solution a drop of saturated solution of quinine sulphate is added as an indicator. The fluorescence is small while the solution is alkaline, but the approach to acidity is shown by an intense blue fluorescence due to the formation of the acid sulphate of quinine.

Natural substances can be differentiated from synthetic products by ultra-violet rays, real diamonds from imitation stones, artificial from real amber and vegetable from mineral oils.

In more ordinary life, adulterants and impurities in foodstuffs can be detected, while recently a novel case appeared in the Courts in Glasgow where a person was charged with removing from eggs the mark of the country of origin. Nothing was visible on the suspected eggs in daylight, but examination under the ultra-violet rays in a cabinet such as that shown in Fig. 15 at once showed up the mark which had been removed and a conviction was secured in this way.

Mildew and bacterial damage on wool, though invisible in daylight, shows strongly under ultra-violet rays, and examination by this means is in regular use for the inspection of raw and worked textile materials, papers, dyes, and other materials.

In the dyeing industry the rays are being employed for testing the fastness of dyes, and in the leather industry they are being used for improving the quality of patent leather.

It will thus be seen what a large part ultra-violet rays are coming to play in our daily life.

IRRADIATED FOODSTUFFS.

Another aspect of their use is the **irradiation of foodstuffs**. Much work has been done on this subject. Steenbock and Daniels[174] found that the exposure to ultra-violet rays of foodstuffs such as wheat, rolled oats, cream of wheat, shredded wheat biscuits, corn cakes, patent wheat flour, corn starch, meat, milk and egg yolk endows them with rickets-preventing properties. That such a wide variety of foods can be thus affected appears to be due to the fact that practically all naturally occurring foods contain lipoidal constituents of the nature of sterols which can carry this activation. Hess[175] found that vegetables such as carrots and spinach can be made anti-rachitic by

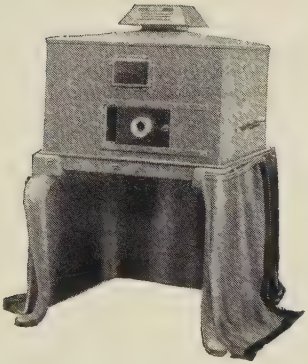

FIG. 15.—Kelvin, Bottomley and Baird Quartz Fluorescence Cabinet.

means of ultra-violet rays and that they retain this property even after cooking. He found, however, that irradiation of cod-liver oil renders it less potent anti-rachitically.

It is well known now that irradiation of milk increases its anti-rachitic properties, but various observers have pointed out that the vitamin A is destroyed, and that other changes occur which are not desirable. Many contradictory results are reported. Dawkins and Pattison [176] found that radiated milk had a greater food value than non-radiated milk. Feeding five tuberculous children with it increased their red cells and hæmoglobin, the rest of the diet being as before. When the radiated milk was stopped the reds fell in each case and the hæmoglobin in four out of the five. Again giving the radiated milk increased the reds, but the hæmoglobin varied.

Drummond [177] warns against feeding with irradiated milk. Radiated milk becomes unpalatable as it acquires an unpleasant tallowy odour, and has its vitamin A destroyed by oxidation. If the children are fed on it and receive insufficient vitamin A supply otherwise, they may show the retarded growth and lowered resistance due to insufficiency of vitamin A in the diet.

Hottinger [178] states that the addition of sugar to dry milk protects it from loss of vitamin A during ultra-violet radiation.

Scheer [179] has not noticed any harmful effects following the use of irradiated milk. He considers such milk better than pure ergosterol preparations in the treatment of rickets, because overdosage is impossible with the former, whereas with the latter it is not only possible but dangerous. He believes that irradiated milk will play an important part in the future in the prophylaxis as well as in the treatment of rickets.

Adams,[180] on the other hand, believes that the use of such milk is not practical and prefers to use milk to which radiated ergosterol has been added.

Hess[181] found that less irradiation of milk will prevent the development of the unpleasant taste, and it has the additional value of avoiding the destruction of the fat soluble and anti-scorbutic vitamins of the milk.

Chalmers Watson and Finlay[182] recently reported beneficial results in the treatment of rickets by means of irradiated milk. They get over the difficulty of the destruction of the vitamin A by mixing radiated milk with non-radiated milk in the proportion of one part of the former to two of the latter. They do not consider, however, that radiated milk should be used as a complete substitute for good fresh milk in children on account of the danger of premature ossification.

Many radiated drugs have been put on the market, and glowing accounts are given in the advertisements of the beneficial results obtained from their use. The whole of this subject is so new that opinion as to their value has not yet definitely crystallised. At a discussion at the Société de Médecine des Hôpitaux de Paris[183] it was stated that irradiated substances lose their activity in about three months. If this is the case, the probability is that a large proportion of such substances, both drugs and foodstuffs, on the market are worthless as regards any virtue conferred on them by radiation, and to protect the public the packages or labels would require to have a date stamped on them before which such substances would have to be used, as is already done in the case of certain vaccines. I am informed, however, by the holders of the patent rights in this country for the irradiation of drugs and foodstuffs, that irradiated substances are not inert at the end of three months, and that they show practically no deterioration

at the end of eight months. This statement is supported by the results of Steenbock,[184] who found that even after twenty-eight months there was no decrease of potency. At the same time, many experiments have been recorded in animals in which the use of highly irradiated substances has led to abnormal calcification in the cardio-vascular and renal systems. Under these circumstances, it would seem wiser not to prescribe such substances generally until observations have proved their value and shown that no danger to the health of the individual exists.

GLASSES PERMEABLE TO ULTRA-VIOLET RAYS.

Mention must be made of the glasses which can pass ultra-violet rays and of which there are several varieties on the market. There can be no doubt that such glasses do allow the rays to pass, but whether or not they are of any real value as regards the health of the population is a different matter. Interested manufacturers give glowing accounts of the benefits derived from the installation of such glasses, and demonstrations are given showing the large proportion of ultra-violet rays which penetrate these glasses. These demonstrations are not given with solar rays but with artificially-produced rays and generally from iron-cored carbons or some such source which gives rise to a large amount of the short ultra-violet rays. The manufacturers do not say that the solar ultra-violet spectrum stops at 2900 Å.U., and that even in summer a considerable amount of this is cut off in our towns by the soot and dust in the atmosphere. In winter the proportion of ultra-violet rays which get through in our towns is negligible. Watt[185] of the Department of Health for Scotland found that in his garden in one of the suburbs of Edinburgh the amount of ultra-violet rays

recorded by the methylene-blue indicator during the months November to February was inappreciable, and that it was very small in the country. It was also estimated [186] that on an average April day one might require to expose the white skin of the arm to the rays of the sun from sunrise till midday to produce perceptible reddening of the skin.

While more rays get through in the south of England, the statistics given [187] do not refer to large manufacturing towns, but to comparatively small health resorts. It is in the large towns that the benefit of ultra-violet rays is most desirable. If no ultra-violet rays penetrate to our large towns in winter, of what use is it to instal in these towns an ultra-violet-passing glass? It cannot possibly let through what is not there.

Early in 1929, I was asked to interest myself in two types of such glass. In one case I requested the manufacturers to give me a demonstration of the amount of solar ultra-violet rays which would pass through their glass if it were placed in my garden. It did not in the least surprise me when they declined to give me such a demonstration, nor have I yet been invited to their office in a large town to see the demonstration there, as they promised.

Even granting that the rays did penetrate through the soot and smoke and a certain percentage reached the glass, the glass has to be kept clean, a point which is not sufficiently stressed. In towns a film of grime would soon spread over the window and the glass would require to be cleaned daily, otherwise this film would soon stop any effective rays. It is interesting in this connection to note that efforts were made to persuade the London County Council [188] to use one of these types of glass for the class-room windows of the county schools. The proposal was negatived owing to the

belief that the installation would be of no effect as daily cleaning within and without would be necessary to preserve the special qualities of the glazing material.

But even if this were done, it does not seem to be sufficiently realised that those who wished to benefit would have to sit undressed. If only the skin of the hands and face were exposed, little or no benefit would accrue. In summer with the modern facilities for getting out of towns, more benefit would be derived from an afternoon in the country than from sitting behind such a glass all day. It has been shown [189] that even in towns a person gets more ultra-violet rays by going out into the direct sunshine during the lunch hour than would be obtained all day behind a window of ultra-violet-transmitting glass. Besides, it is really in winter when milk and butter are deficient in vitamin D that we want all the ultra-violet rays possible, and as has been shown above, the amount reaching our towns is negligible. It would thus appear that the installation of these special glasses in our houses in towns is a sheer waste of money, and that the only people likely to benefit from such a proceeding are those interested in the sale of such glass.

In the country, for ordinary purposes of retaining health, such glass is entirely unnecessary. By going out of doors much more benefit would be obtained. Even if a person were confined to bed, little benefit would be derived during the winter with such a small amount of ultra-violet rays reaching the ground, and to obtain even this trifling benefit an exposure of the naked skin of a considerable part of the body would be necessary. During the summer, it would be better to get the bed to the open window and let the sunshine or skyshine reach the patient without the intervention of any glass.

It is, however, a different matter in spring, when the sunshine begins to have an appreciable amount of ultra-violet rays. Not infrequently it is found at this season that the sun is shining, but that the air is too cold to allow a patient to lie exposed at an open window. Under such circumstances the use of these glasses in the sick-room in a private house or a convalescent or similar home in the country would be beneficial. The patients could lie uncovered behind such glass no matter how cold the outside atmosphere might be, and the ultra-violet rays would pass through and impart their health-giving properties to the sufferers. Apart from such circumstances, however, it appears to me that there is no advantage to be gained by the use of these special glasses.

This opinion is strengthened by a conversation I had recently with a partner in a large nursery. This firm had tested three different types of ultra-violet-passing material for some of their frames. In only one material tested was there much of an increase in the weight of the vegetables grown, and indeed in one the weight was less than that of the vegetables grown under ordinary glass. While the increase in the first case was definite, it was not thought sufficient to make the installation of this material a commercial proposition as it was very doubtful if any increase would be obtained in the price received for their produce.

One place does give proof of a value for such a glass, and that is in poultry farming. Here the chicks frequently cannot be allowed out when they are young on account of inclement weather. If the sun were shining and yet the air too cold and the weather boisterous, the chicks would receive the benefit of the ultra-violet rays in the spring sun, if they were behind such a glass.

Apart from these few exceptions, however, it would seem that these special glasses are useless in towns and unnecessary in the country. It is difficult to see what other conclusion could be arrived at. As long as our towns have a large amount of soot and smoke in the atmosphere, the ultra-violet rays will be cut out and be prevented from reaching the neighbourhood of our houses. The real solution of the problem would seem rather to be the production of a smokeless fuel at a price which would make it possible for all to purchase it. Along with this would be the education of the public so that such a fuel would be bought instead of ordinary coal. This day is a long way off, but because it is distant we ought not to refrain from trying to reach this goal. In Scotland we have a saying, "Every pickle maks a muckle." Every little helps, and while individually we may not be able to do much, yet each one trying to educate and influence those around him, in the end the whole mass will be leavened, and real advance towards the improvement of the health of the people will be made.

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